JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXLVIII, No. 5. 74TH YEAR. NOVEMBER, 1899

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CHEMICAL SECTION.

INTRODUCTORY ADDRESS.

BY DR. JOSEPH W. RICHARDS,
President of the Section.

[Commemorative Meeting held in Convention Hall, National Export Exposition, Monday, October 2d, on the Occasion of the Celebration of the Seventy-fifth Anniversary of the Franklin Institute.]

The Chemical Section of the Institute, being the oldest of its sections, has been charged with the pleasant duty of inaugurating the proceedings of this commemorative week.

Chemical science has always been prominently represented among the Institute's membership. The organizer of the Institute, Samuel V. Merrick, was himself a practical mechanician, but he had as his co-worker William H. Keating, Professor of Chemistry at the University of Pennsylvania, and these two sent out together the first call for a preliminary meeting. Thus mechanics and chemistry conjointly presided at the birth of the Institute, fittingly typical of its future sphere of activity.

As soon as the Institute was officially organized, Professor Keating was appointed its professor of chemistry, thus from the start recognizing and confirming the prominent relation which chemical science was meant to sustain towards the work and objects of the Institute.

The duties of the Institute's professor of chemistry appear to have been the delivery of a graded course of lectures to students and apprentices, the arranging of lectures by prominent specialists in chemistry, the editing of chemical communications offered to the Institute for reading and publication, giving criticism and expert advice to the Committee on Inventions and Discoveries, and acting as conservator of the chemical apparatus and equipment of the Institute. With the establishment of the Philadelphia High School, and the general development of the higher educational facilities in and around this city, the graded course of lectures became superfluous, and, on the organization later of the Chemical Section, the functions of the professor of chemistry have been shifted to it and its various committees.

In 1881, the chemical work of the Institute was of sufficient importance to warrant the formation of a distinct section for the discussion of the particular problems of pure and applied chemistry. It was true then, as now, that at the general meetings of the Institute only questions of general scientific interest can be brought forward, while problems of interest only to professional chemists, or capable of being understood and discussed only by such, were necessarily excluded from the program. The chief advantage of the formation of the section was that it enabled the chemists to come together at their own meetings, to discuss without the distractions of a general assemblage the higher problems of chemical science and industry. The result was the immediate enlargement of the sphere of the Institute's activity.

This principle of the subdivision of the Institute's work has been so fruitful of results that the example thus set has been followed by the formation of no less than four other sections and one sub-section. Specialization is to art and

science what division of labor is to industry; it is the modern method of setting every one to work and reaching large results. The creation of each new section has been a distinct gain to the Institute, stimulating individual effort in the directions thus specialized and reacting on the rest of the membership by the general increase of interest in the Institute's work.

This year has seen the principle extended to a still greater degree, the organization of the Photographic and Microscopic Branch of our Section having been such a success as to amply justify its formation. As you may see from the program, the latter half of this evening's proceedings are in their hands. The creation of new sections as rapidly as circumstances will justify their formation is therefore *the* characteristic of the Institute's present policy, and the ideal condition of the Institute's plan will only be attained when every prominent branch of science, art and industry has its appropriate section, and every member of the Institute, whatever his specialty, can be thus enrolled among congenial co-workers. The perfected plan will result in a republic of free and independent sections under the general presidency of the parent Institute.

Previous to 1881, nearly a hundred original communications on chemical subjects had appeared in the *Journal* of the Institute. Since then, the Chemical Section has held 174 meetings and listened to 215 lectures or papers. A free discussion has always been a characteristic of the meetings. The subjects treated have ranged from the most prosaic details of applied chemistry to the most refined speculations of pure chemistry.

One striking characteristic of the illustrious Franklin was undoubtedly his intensely practical as well as philosophic mind. The Institute which so worthily bears his name, true to its great prototype, has always stood for the happy combination of theory and practice, the union of pure and applied science. But, in no art or industry is the interdependence of theory and practice, the coördination of the laboratory and the workshop, more intimate than in chemistry. The atmosphere of the Institute has,

therefore, been particularly favorable to the development of the chemical arts. Here, in its halls, have met students and workmen, teachers and business men, thinkers and doers; and sitting side by side, each has learnt from the other and all have been mutually benefited.

Aside from this characteristically democratic tone of the meetings, members of the section have been peculiarly favored in several other respects, such that probably no other chemical society in America offers its members equal advantages. Briefly referred to, they are as follows:

(1) The use of the Institute's library and reading-room. The library is particularly rich in old and rare works on chemistry. One of our recent lecturers, coming from Washington to lecture on the history of pneumatic chemistry, expressed himself publicly as surprised and delighted at the wealth of old chemical literature on our shelves, some of the works being so rare that, although familiar with their names, he had never until that time been able to actually see them. Besides these, the wealth of journal literature, that most useful to every kind of chemist, is extraordinary. Among the 400 journals on file in the library, most of them complete, are fourteen concerned exclusively with chemistry, and no less than eighty-three partially. The value of complete sets of American, British, French, Swiss and German patent literature also merits that they be mentioned in even the briefest allusion to the library. Recent works on chemistry are only fairly well represented, but a committee of the section is at present busily engaged in removing this deficiency. Taken all around, it is certainly the equal, and possibly the superior, of any other chemical library in America.

(2) The frequent lectures on live topics by distinguished specialists. The lecture list of the Institute has been particularly rich in chemical lectures of high grade by specialists in their profession. The privileges of members in this regard during the last few years have been exceptional. Time does not permit any further particularization; the presence with us to-night of our distinguished colleague from Washington, to add interest to our proceedings by an

address, will illustrate and emphasize anew this very valuable feature of the section's work.

(3) Immediate and effective publication. The *Journal* of the Institute is unsurpassed among scientific journals for giving immediate and world-wide publicity to its contributions. Passing out to several thousand members and subscribers, finding its place on the files of all scientific libraries, and, particularly, by means of its 400 exchanges entering at once into the hands of scientific editors everywhere, to be quoted, translated, extracted from, discussed—its communications are assured, in the most effective manner, immediate publicity in the scientific world.

(4) The use, at present, of a considerable stock of chemical apparatus; and, prospectively, of a laboratory to use it in. Thanks to the liberality of several members of the Institute, the store of chemical glassware, porcelain, balances, microscopes and photographic apparatus now in the possession of the section is large and costly. Nearly $2,000 worth of such material recently came to us from the estate of Dr. M. Carey Lea alone. This apparatus is primarily for use in illustrating lectures and papers at the Institute, but recent action of the section has placed it at the disposal of any of the members, to be loaned out under suitable regulations.

It is just here that there is a splendid opportunity for extending the usefulness of the section. The apparatus already owned by it would equip several rooms for research work in chemistry, metallurgy, mineralogy, photography, microscopy and allied fields. Such a laboratory would be at the disposal of committees appointed to investigate special questions, or allow any member to translate his ideas and suggestions into experiments. It was a saying of Deville, that "It is not necessary to theorize if you can make the experiment," and who can tell how many bright ideas, valuable suggestions, pregnant thoughts have been called into being at our meetings, and yet have failed of fruition because the member thinking them had not the facilities for making the light-bringing experiment. Great ideas are probably as rare as great geniuses, but it is our

right and duty to nurture them wherever there is a possibility of their developing. May we not express the hope that in the near future the idea of such laboratories may materialize, to the great advantage of the membership and increase of usefulness to the Institute?

The Chemical Section is thus seen to be prodigal in the advantages it offers its members. To the Institute itself it is of service in providing a definite organization for the handling of a definite part of its business. The investigation of chemical questions, the care of the chemical equipment of the Institute, the oversight of the chemical division of the library, the entertainment of distinguished chemists, fall naturally to its committees or members. Granted, however, that a well-arranged laboratory is added to our resources, for which we already possess the equipment, and there may develop a public function or relation of the section to the community which would be by no means unimportant. There are many questions of importance to the community which committees of the section, working in its own laboratory, would be able to solve without fear or favor. Such important matters might be an examination of the municipal water supply, tests of the adulterations in foods, fixing of standards of purity of foods, examination of the material proposed for public monuments, the effectiveness of methods of disposing of sewage, etc. There are, of course, officials already charged with the nominal fulfilment of such duties, but the committees mentioned, rendering unbiased decisions solely for the benefit of the community or commonwealth, would constitute a court of last resort on all such debated and unsettled cases, which would prove of great public value.

We felicitate the Institute and the Chemical Section on the work already achieved. We thank our members for their unselfish devotion, and call on those present to sustain the high standard which has been attained.

We extend a hearty greeting to all our friends who are joining in our celebration, and particularly to visitors and the speakers from a distance, who, at the expense of time and effort, have thus shown their interest in our work.

It is with satisfaction and pleasure that I now introduce the first speaker of the evening, a distinguished colleague, an honorary member of the Institute, ex-President of the American Chemical Society, and Chief Chemist of the Department of Agriculture, Dr. H. W. Wiley, of Washington, the subject of whose address is "The Relation of Chemistry to the Advancement of the Arts."

THE RELATION OF CHEMISTRY TO THE ADVANCEMENT OF THE ARTS.

BY HARVEY W. WILEY,
Honorary Member of the Institute, Chief Chemist to the U. S. Department of Agriculture, Washington, D. C.

[An address delivered in Convention Hall, National Export Exposition, Monday, October 2d, at the Commemorative Meeting of the Chemical Section, on the Occasion of the Seventy-fifth Anniversary Exercises of the Franklin Institute.]

The founding of the Franklin Institute, three-quarters of a century ago, marked the inception of a new relationship in this country between science and the useful arts. In the foundations here laid were provided the means whereby the generations which were to come, who would be deprived of the advantages of academic and technical training in the great institutions of the country, might yet come into touch with science and feel the impetus of its practical application. The provisions here made were not intended for the millionaire, or even the well-to-do citizen, but were planned for the benefit of the artisan, the laborer and the workingman whose intelligence enables them to comprehend the true meaning of science and whose tastes and industry incline them to take advantage of it.

The Franklin Institute was the forerunner of many institutions of similar import which have since been established in the different parts of the country. Among these may be mentioned the Cooper Institute, of New York, the Pratt Institute, of Brooklyn, the Lowell Institute, of Boston, and the Armour Institute, of Chicago. These great centers

for the distribution of practical knowledge are all established upon the general principles which guided the founders of the Franklin Institute in the great work which they have accomplished.

Science, in order to become useful to man, must be vivified by coming into contact with man's industries. It is a misnomer to apply the word "pure" to a science which is latent, and yet we constantly see in the text-books and hear in the lecture-room the expression "pure sciences," meaning thereby research for truths not intended for immediate practical application. I would detract nothing from the dignity of research, nor from the glory and honor of the achievements in the realms of abstract investigation, but I do protest against discrimination which is made or which may be made, in the public judgment, in the use of terms which, to the general reader, may convey a wrong impression. If one branch of science is pure, there is an inclination to believe that another branch is less pure, or is even impure. Whereas, in point of fact, all branches of scientific investigation and application occupy similar positions in their claims upon the attention and the guidance of humanity.

The severely practical man thinks that there is no justification in delving for knowledge for which there is no immediate practical application in view. He should remember that any addition to human knowledge is finally not without some application to human progress, and, however abstract and impractical the results of an investigation may seem, if they afford new light and new knowledge, they will, some day or other, justify the time and the labor which have been consumed in obtaining them.

On the other hand, the devotees of pure research sometimes admit no justification of practical application, and view with contempt the efforts of those who seek to apply for immediate use the great principles underlying scientific investigation. These, however, have some claim for recognition also, and stand upon the same foundation of truth as the scientific anchorite.

If we look casually over the great constructive arts and

industries of the world, we find that they are all practically based upon three great sciences, namely, mechanics, physics and chemistry, and these three sciences are the fundamental ones underlying the great activity of the Franklin Institute. To one who has never had his attention called to this subject, a surprise is in store if he considers carefully the above statement. Whatever be the industry to which his attention is called, he will find that in its inception, its development and its attainments the three great sciences mentioned have played a most prominent part.

Other speakers will call your attention, doubtless, during this anniversary week, to the relations which mechanics and physics bear to the arts. I am invited to-night to say something of the relationship which the science of chemistry bears to the progress of the useful arts. In doing this I disclaim at the outset any intention to minimize the influence which any other science, and especially those mentioned above, may have had upon the development of the industrial life which at present dominates the progress of humanity. While, of course, from my point of view, to-night, chemistry is the chief factor of this dominating influence, you will have this progress exhibited to you from other standpoints before these anniversary exercises are concluded.

During the short time allowed to this address I shall not endeavor to go into elaborate details in regard to any one of the useful arts, but shall rather attempt, in a general way only, to establish clearly the influence which the science of chemistry has had upon industrial development; in other words, to elaborate, at least in outline, the philosophy of industrial development in its relations to chemistry.

Man, in the exercise of his activities, has at his command the raw materials which nature affords, or which he himself produces, and the natural forces which may be directed in the elaboration and utilization of these materials. The changes which matter undergoes in its transformations are, as is well known, twofold, namely, mass changes and molecular changes.

If, for instance, a block of iron ore be transported from

Lake Superior to Pittsburgh, we have change of mass or mass motion. If, after it is left at Pittsburgh, the ore is placed in a furnace and reduced to the metallic state, we have molecular motion, in which the character, properties and appearance of the mineral are radically changed.

Now, in all the industries, no matter what they may be, these changes of the molecular nature of substances are the principal ones to be considered. In the fundamental one of all, namely, agriculture, we see the most striking illustration of this principle. The scientific agriculturist has at his disposal certain elements in the soil and in fertilizing materials, as well as the natural forces, which, aggregated, may be designated as meteorology and climatology; in other words, the forces of water, heat, light and air, in the exercise of his art. His purpose is to transform the elements of plant food into organic products suitable for the nourishment of life and for other useful objects. Every one of these changes is of a chemical nature; in fact, in no industry has the fundamental basis of chemistry been so generally recognized as in the science of agriculture.

In the development of agricultural industry during the past fifty years, there have been founded in all parts of the world agricultural experiment stations, for the study of the principles underlying scientific agriculture. A glance at the names of the directors of these stations will show more strikingly than any other illustration the dominant influence of chemical science. I lately had occasion to look over the names of the directors of the agricultural experiment stations of Germany. I found that more than 70 per cent. of the men who are in charge of scientific investigation, from an agricultural point of view, in the German Empire, are professional chemists.

In our own country, out of fifty agricultural experiment stations now in existence, twenty are directed by professional chemists. But the dominant influence of chemistry in the agricultural stations of this country is not measured by the relative number of professionally trained chemists who are directors of the stations alone, but by the importance of the work done by these stations as compared with

that performed by the others. If one well posted in the matter were asked to name the fifteen most successful agricultural experiment station directors of the United States, I am sure almost every one whose name would appear in the list would be one of the twenty mentioned above.

A much larger proportion of the total number of directors, doubtless, would be found in the chemical profession were it not a very prevalent custom in this country to make the president of the agricultural college also the director of the station, which is usually located at the same place and is under the same board of managers.

Another fact which emphasizes more than those already mentioned the dominant influence of chemical science in the station work is that, of the remaining thirty directors, cited above, very few have had professional scientific training of any kind. In the hasty organization of the agricultural experiment stations of the United States it was found impossible to get professionally trained experts in all cases for directors. In many instances the men chosen had no other preparation than the ordinary college course. Among the station directors, therefore, there is no science which has any prominence whatever, in the way of professional application, aside from chemistry. As an illustration of this, it is only necessary to attempt to name the directors who have been trained as engineers, physicists, botanists, entomologists, geologists or in any of the other well-known sciences. It is probable that there may be one representative of some one of these among the various station directors, but of some sciences there cannot be found even one representative. It may be stated broadly, therefore, allowing for an occasional exception, that chemistry is the one science which is professionally represented in the directorate of the experiment stations of the United States.

In point of fact, the agricultural experiment stations of the United States which have been directed by chemists have taken such a leading position in the development of agricultural science as to practically monopolize all those investigations which have been most useful to agriculture throughout the country.

Among the working forces also of the experiment stations, chemists predominate. There are three times as many chemists employed in the stations as there are those engaged in other professional scientific work. For instance, the number of chemists employed in the agricultural experiment stations of the United States is 157, while the total number of botanists is fifty, and the total number of entomologists is forty-two. Furthermore, the number of other professional scientists employed in the stations is still less even than the number of botanists and entomologists. The number of chemists, therefore, engaged in chemical work in connection with the agricultural stations of the United States is considerably greater than that of *all* others working along other scientific lines.*

The dominant influence of chemical science, however, does not stop with those studies which treat of the processes whereby the inorganic materials of the earth's crust, air and water, enter into organic forms suitable for the sustenance of organic life. Directly following the study of these products is that great class of agricultural chemical technics, whereby the raw materials produced in the fields, gardens and orchards are converted into other products. There is no branch of agricultural chemical technology which is not based upon chemistry and its applications. I need only enumerate the great industries of this class to emphasize my statement. Among these may be mentioned tanning, brewing, distilling, starch manufacture, glucose manufacture, sugar manufacture, wine making and many other similar industries. In each one of these great technical arts, chemistry is the fundamental science whose applications bring success. The time is passed when it is possible to conduct any of these great industries without the direct or indirect aid of chemistry. In many cases a professional chemist is the director or manager of the factory. This is almost universally true of the glucose and sugar manufactories of the world. In the brewing industry the

* If a census were made of the European stations, there is little doubt that the result would be exactly similar.

work of the chemist is of no less importance, although his managerial participation in the work is more limited; and so with all the other industries of this nature.

A cursory study of the processes employed in these great technical operations will show that almost all the progress which has ever been made therein has been due to chemical research. The changes which raw materials undergo in manufacture are almost wholly of a chemical nature. A proper understanding of these changes is the first step necessary to their most economical and perfect operation; therefore, if at the present time all participation of chemical knowledge and its applications in the great technical industries were to be entirely suspended, there would be no further progress in these lines of work, and at the end of 100 years instead of an advance, we would find a retrogression in them all.

I have spoken of agriculture as the dominant industry to which chemistry is particularly allied. I did not do this because I wish to minimize the importance of the other industrial arts with which chemistry is vitally connected, nor because agricultural industries are the ones with which my life-work has been most intimately associated, but because I regard agriculture as the most fundamental art and industry of them all, since without it all the others are impossible. The poorly-fed and poorly-clad nation is the one in which no great industry can thrive. Advancement of a nation in wealth, in power and in influence is conditioned first of all by its food supply; in other words, the development of a nation or of an individual is largely a question of nutrition.

Further than this, the area of the world suitable for agriculture is a fixed one. Man cannot create as well as utilize the fields. First of all, of course, the most fertile and most promising regions are occupied. Little by little the areas less adapted to agriculture are occupied and subdued. When the prairies are exploited the forests are attacked, and when the areas freely watered by the rains of heaven are exhausted, man seeks fresh fields in the arid or semi-arid regions. The floods are dammed and stored up for

future use, and the interior of the earth is tapped to secure the supplies of water which flow in the dark secret channels of the subterranean world. But when all these possible areas are occupied, there will no longer be any increasing acreage for the production of human food. On the other hand, we see the population of the earth rapidly increasing under the impetus which the achievements of science have given to man's powers over nature. It is evident, therefore, that the food of the future must be provided by increasing the fertility of the arable soil of the world. Chemistry is the one science connected with agriculture which teaches man to produce his crops and then leave his fields more fertile than they were before. Hence, to chemistry alone the future world must look for its food supplies. And do you ask, will chemistry be sufficient to meet the demands which the future will make upon it in this direction? My answer must be an assuring one. Under the favoring influence of applied agricultural chemistry the fields of the world are increasing their yields. In the north of France the yield per acre of wheat at the present time is nearly double what it was fifty years ago, and this is but one of the instances of what scientific agriculture has been able to do.

Unfortunately, in our own country we have, up to the present time, had little occasion to appeal to agricultural science for help. The fertility of our soils and their vast area have rendered the farmer, to a certain degree, independent of scientific help. But the time has now come when the most productive part of our country is fully occupied. Already we begin to feel the stress of the agricultural population bearing upon the borders of the arid regions, and asking national and State aid for the development of water supplies and the recovery of the arid lands. The level forests and the arable prairies of the humid regions have been fully occupied. In fact, so many of the trees have been felled to make place for the plow as to excite the concern of thoughtful men in regard to the preservation of our forest domain. The time has, therefore, now come when we must look to an increasing yield rather than to an in-

creasing area for the greater food supplies which the future will demand. I, for one, have no doubt of the ability of chemical science to respond to the call which will be made upon it to supply the coming generations, numerous as they may be, with abundant stores of food.

I have spoken thus at length of the intimate relation which chemistry bears to the art of agriculture, not alone because it is the particular theme assigned to me, nor because it is the one which most nearly interests me, but because I believe it to be a question of the most vital importance to our whole people. I would not, however, minimize the importance of the relations of chemistry to the other industrial arts which go to make up the prosperity, the wealth and the glory of our country.

The organization of this great exposition, the first one of its kind ever held, shows you how, in the applied sciences and technical skill of the United States, we are reaching out for the markets of the world. In every one of the technical arts represented in this great exposition chemistry forms an essential part. If I call your attention to metallurgy, which is purely a chemical science, there is, perhaps, no boon, after the production of food, more grateful to mankind than the cheapening of the metals which are necessary to the various industrial arts. Chemical science, combined with mechanical skill, has accomplished this most desired result. Iron and steel not only form the framework of our great buildings which push their attics skywards in our large cities, but I may say that they are the framework and skeleton around which our wonderful nineteenth century has been built. They have as intimate a relation to the progress of mankind as they have to the support of the walls of the building of which they are the frame. By chemical processes many of the ores of gold and silver, which a few years ago were so refractory as not to be fit for use, now yield abundant supplies of the precious metals. The supply of gold has become so great that it has become the money standard of the whole world, with a few insignificant exceptions, and, even in those countries where it is not the adopted standard, we already see signs of a

movement to make it so. Thus, from the metallurgy of this one metal alone, we see that the whole commerce of the world is now based upon a single standard, insuring a degee of stability which has never before been obtained in commercial transactions.

Owing to chemical science another metal also, formerly costly and impossible to use in the arts, has become a common article of commerce. Aluminum, of course, is still in its infancy, and yet we see already that it is destined, both by itself and in combination with other metals, to be of great usefulness to mankind. By reason of its lightness, its toughness and its durability a future day will see it displace the cheaper metals, such as steel, in many structures where steel is now alone employed. I am not here, however, to prophesy the future, but simply to indicate what chemistry has already done up to the present day.

It is unnecessary to multiply instances illustrative of the vital part which chemistry plays in the science of metallurgy, or of the dominant influence which metallurgy has had upon the progress of civilization. Of all the missionaries who have been sent out by devoted men to different parts of the world, it is doubtful if any or all of them have done more to bless mankind than the Bessemer converter.

Metallurgy also holds intimate relations to the art of agriculture, since, in the manufacture of steel from ores and pigs rich in phosphorus, a most valuable fertilizing material, a basic phosphatic slag, has been developed, over a million tons of which are used annually to increase the food supplies of the world. This fact is an illustration of the very intimate relation which chemical research establishes between all the arts and sciences into which it enters.

The science of chemistry has undergone such a wonderful evolution during the past one hundred years as to make some of its branches almost strangers to others. The term chemist at the present day no longer indicates one who is thoroughly acquainted with the entire science of chemistry, but rather one who practices some special branch of the science. There is no living man who can be said at the

present time to understand the science of chemistry as a whole, in the sense of expert knowledge. It is true that one who reads the literature of the day, even in the form of extracts, may have a general knowledge of advanced chemical science and the broad principles upon which it rests. But it requires a lifetime devoted to a special study to become an expert in that line. As illustrated by the intimate relation between two branches of science, apparently so remote from each other as the two cited above, it is evident that there is no real separation between any two lines of chemical research, but that all the workers in this science should recognize their universal fraternity.

Another very apt illustration which will occur to every one, of the influence of chemical research on industrial art, is seen in the development of the coal tar coloring dyes. Fifty years ago coloring matters were mostly natural products, and very few artificial coloring matters were known save those produced by grinding metallic oxides in oil. The vegetable world was the source of a great many of the principal dyes employed in the textile industries. Indigo, madder, turmeric and other vegetable coloring matters were the principal ones employed in the dyeing of many fabrics. To-day we find a complete change in the technique of coloring. From an apparently waste product there have been developed a series of colors which are at once brilliant, permanent and cheap. The development of this industry was due solely to chemical research, without any idea of practical application. As soon, however, as it was discovered that coal tar contained the basis of so many varying tints, rapid strides in their practical application to the textile arts were made. To-day, if the coal tar colors were removed from this industry, it is no exaggeration to say that paralysis would ensue and the capital invested in it, of hundreds of millions of dollars, would be compromised.

Not only in the textile fabrics has this great influence of chemical science been felt, but even in the case of the colors used in food products we find that the coal tar tints are gradually replacing the natural vegetable coloring matters in the markets. We find that candies, confections, pre-

serves, jams, jellies, butter and oleomargarine, at the present time, are colored by tints made from synthetic products, to the practical exclusion of the natural vegetable coloring matters, which, a few years ago, were used altogether. I say nothing here in regard to the hygienic effect of this change; that is a matter which could only be properly discussed upon another occasion. I have spoken only of its commercial aspect, and have endeavored to present to you the triumphs achieved by chemical science in rendering the products of nature more expensive than those of synthetic chemical skill.

This fact leads to the discussion of another very important rôle of chemical discovery in the industrial arts, namely, the continued manufacture of synthetic products, which are cheaper and, therefore, commend themselves more generally to the public use than those formed by the ordinary processes of nature. Chief among these may be mentioned the hundreds of materials now used in pharmaceutical preparations. I have very little to say in favor of the use of drugs and medicines of any description, but in this general review of the accomplishments of chemical research one cannot shut his eyes to the fact that in pharmacy the synthetic relations of chemistry have assumed a very important position. One has only to look over the list of remedies, both official and proprietary, to see the great inroads the chemical laboratory has made upon the fields which heretofore were supposed to be reserved only for natural products. The old natural remedies of herbs and roots are now very largely superseded by the artificial products of the retort and the crucible.

In the case of beverages, we find that a change has been wrought, also, in the substitution, for products made by natural methods, of those produced by chemical synthesis. Especially is this true of those beverages which depend largely for their reputation and flavor upon the ripening influences of age. It is well known that certain kinds of beverages, such as wines and the distilled liquors, known as whiskies and brandies, when properly supervised and kept, become mellower, more palatable and more wholesome

with the passing of time. These changes, which are so appreciated by the consumer, are due solely to chemical reactions which the liquors undergo. In the crude state they contain alcohols which are both unpalatable and unwholesome. Slowly, under the proper conditions, these alcohols are oxidized to form the ethers and other aromatic compounds, which add to the odor and the flavor of the beverage and make it more palatable and more wholesome. The chemist was not slow to discover the nature of these changes, and to produce in a synthetic way, in his laboratory, the exact substances which nature produces in the ripening process. It was found that all these ethers and aromatic substances could be made in the laboratory, and at a much less expense than they could be produced in the bonded warehouse, by natural methods. It was, therefore, possible to mix a pure alcohol with the necessary ethers, essences, flavoring and coloring matters, in the composition of an exact counterpart of a very old whiskey, and this mixture could be made so skilfully that both the chemist and the connoisseur would be puzzled to discover any difference between the genuine and artificial beverages.

Perhaps I should say a word here, also, in regard to the claims which have been made in many quarters that chemical science will eventually permit the synthetic production of human foods, to the practical exclusion of the ordinary pursuits of agriculture. These predictions are not without some foundations in fact, for since the day, now three-quarters of a century ago, when Wöhler and Chevreul succeeded in passing the border line which had been supposed to separate the inorganic from the organic world, and produced actual organic compounds, hundreds of substances of an organic nature have been formed directly by chemical synthesis. Among those bodies which could serve as foods, the fats and sugars are the most prominent, while it is only of late years that bodies having the properties of protein matter have been formed by synthetic operations. Since animal bodies are sustained almost exclusively by food of an organic nature, it is evident that all progress in this line has some bearing upon the food of

the future. The fact remains, however, that all these organic compounds are produced at such an expense as to render them practically impossible for food, even if they possessed all the digestive properties necessary to nutrition. Further, it may be said that organic synthetic products do not seem to have the same relation to the digestive enzymes as is held by the natural products. It seems, therefore, unwise to expect even in the remote future that any considerable part of the food of man will be produced directly by artificial synthesis.

It is true that several distinguished men of science have prophesied the coming of the day when such a consummation would be fulfilled. Chief among these may be mentioned Berthellot, the distinguished French savant, who has foretold the day when all the cultivatable area of the world will be nothing but one grand pleasure park and the surface of this beautiful earth will no longer be desecrated by the vulgar plow. Man, removed from the necessity of toil and living upon the bounty of the chemist, will devote his time to study and pleasure and the millennium, so long expected from theological sources, will at last have come about from the accomplishments of the chemist.

These ideas must be characterized as dreams of the vivid imagination or as the pleasantries invoked for the amusement of an audience, rather than as the sober deductions of scientific truth. I have already indicated the magnificent work which the chemist is doing and is to do for agriculture, but it is not along the line just indicated. The remotest future that the scope of our imaginations can picture, in my mind, will see the food of man produced in the fields and the science of agriculture developed to the highest point of production, chiefly through the accomplishments of chemical science. But, in denying to chemistry the possibility of a complete triumph in the production of all human foods, I do not mean to imply that the prosecution of chemical synthetic research and its application to the industrial arts will not do much to ameliorate the condition of man.

A mere glance at all our industries of the present

day shows how great this amelioration has already become. The capacity of the laboring man to produce useful things, both in the field and in the factory, is increasing day by day, and this increase is due, in my mind, chiefly to the accomplishments of chemical science. It is true that labor-saving machinery has done much, but labor-saving machinery of itself would tend to diminish the demand for labor, and thus to increase the burdens of the laborer. Were it not for the fact that labor-saving machinery, which spares the hands and muscles of the laborer from much drudgery, is accompanied with scientific research, which places the powers of nature more certainly within the control of man, it might prove a curse instead of a blessing. In point of fact, the improvements in labor-saving machinery have been accompanied with an advancement in our knowledge of the laws of nature and of the methods of utilizing to the best advantage the raw materials at our disposal. The sum of all these accomplishments is that a day's labor to-day produces many times more than the result of a day's labor 100 years ago. And this has been accomplished, happily, not by diminishing the compensation paid to the laborer, nor by increasing his hours of work, but, on the contrary, by decreasing his hours of work and increasing his compensation.

A few days ago I was in conversation with an octogenarian who, having amassed a competence, has retired from active business. He said: "Fifty years ago, when I was in active life, money was worth 10 per cent. per annum, and labor could be had at 50 cents per day. Now," he said, "money is worth only 4 per cent. per annum, and labor is worth $1.50 a day." This is a fact which students of sociology should not lose sight of. Unfortunately, most of the so-called sociologists of the present day are pessimists of the worst type. By their ill-based lucubrations they disturb rather than pacify the public mind, since they convince the laboring man that his condition has never been so bad as it is at present, while in point of fact it has never been so good. All the forces which, in the eyes of some people, tend to depress labor, on the contrary, work to

elevate it. It is true that among our skilled artisans the day of the journeyman and apprentice has practically passed away. Scarcely any one at the present day learns to do everything in any trade. Each portion of the work is specialized, and the artisan becomes as much of a specialist as the scientist. Even the "man with the hoe" can earn his $1.50 a day, and while he may not be a master of French art, he finds in his life plenty of opportunities for improvement and culture. His children go to the best schools; his daughter has an organ in her parlor; the family sits at a table spread with wholesome food in abundance; the morning paper brings him the news of the world, and in the grocery store of the village he finds the fruits and delicacies of tropical lands, mingled with the products of the fields about him. The "man with the hoe" of to-day enjoys more opportunities for culture, more of the joys and luxuries of life than did the millionaire of Athens and Rome 2,000 years ago.

We must recognize this state of affairs as progress, any comprehensive study of which will not fail to reveal the master hand of science in it all; nor will it be difficult to see which science has been the most pregnant factor in producing this fruition at the beginning of the twentieth century.

We find in the achievements of science, and in their applications to practical life, the solution of the great problems which have been the theme of philosophers and poets from the beginning of time. The aspirations of the latter and the logic of the former have from the earliest history of mankind been directed to the amelioration of man's condition.

Whatever be our opinion of the theological view of the origin of man, there is one thing in which we must all agree, theologian and scientist alike, and that is the necessity of labor. What the theologian calls the curse of labor, the scientist regards as the glory of mankind. Labor is only a curse when it monopolizes the whole energy of the individual, but it is a blessing when it directs the forces of man into useful channels of expression. The great work of sci-

ence, therefore, for man, is to change the curse of labor into the blessing of labor, and this it is rapidly accomplishing.

I am not one of those who look at the achievements of science in the distant future to see the passing away of the necessity of labor. If the conditions foretold by Berthellot could be accomplished, and man were left at ease in the beautiful garden of his own creation, all the incentives which produced his power would be taken away and retrogression would take the place of progress. It would not be difficult to foresee the time when this very park of pleasure, built by man, would become again a wilderness, in which man and the lower animals would contend for supremacy. Science, by directing man's labor into profitable channels, will make it a means of his own advancement, and the exercise of his faculties will prepare him to enjoy the fruits of his work.

No matter how tempting a feast, both in the quality of its constituents and in the manner in which they are served, it has no attractions for the man without an appetite. Hunger is the prime factor in the enjoyment of a banquet. In like manner one cannot enjoy rest and the pleasures which it brings who has not worked hard enough to make himself tired. Fatigue is the prime factor in the enjoyment of leisure. So even if science could do what some few enthusiasts claim that it can, it would remove from man the necessity of labor, which, when rationally employed under the direction of science, is the source of his greatest comfort and pleasure.

In what has gone before, a few of the most important ways in which chemistry has come into contact with the progress of the industrial arts have been set forth. In the destructive arts and industries, also, the intimate relations of chemistry are quite as well marked. I refer, of course, to the art of war. The radical changes in the art of war have been due chiefly to chemical research. These researches have been devoted mostly to the elaboration of more powerful explosives. In ancient times, before the invention of gunpowder, battles were fought by the actual coming together of the participants. There was added thus to the horrors of war the bitterness of personal contact. Modern

warfare is almost wholly removed from the possibilities of battle by personal contact of soldiers with the enemy. Thanks to chemical science, those who engage in battle are constantly widening the line between the two opposing armies, so that the modern battle is rather a test of chemical skill than a trial of physical prowess. Little by little chemical research has invented means for carrying projectiles further and with greater destructive force. These advances have been met by a recession of opposing forces, so that in point of fact the destruction by battle is decreasing rather than increasing with the invention of better explosives and improved firearms. One hundred years ago a naval battle was not thought to be complete unless the two opposing ships came into actual contact, and the victors boarded the vessel of the vanquished. The slaughter in such cases was something frightful. In our last naval war, armored vessels, securely riding the sea at a distance of one or two miles from the enemy's fleet, proceeded to the bombardment more as if performing an evolution than as if engaging in actual battle. As a result of the application of chemical science combined with mechanical skill, the victors in the two great recent naval battles scarcely lost a man, and the sailors of the defeated vessels were quickly picked up and preserved by their conquerors. The dictates of humanity require that if a war is to be fought, it should be short, sharp and decisive. Chemical invention has rendered it possible to bring even a great war to a speedy close, with an aggregate saving of human life, so that even in the destructive arts and industries chemical science has done much, not only in the accomplishment of speedy results, but also in the conservation of human life.

When it comes to the care of the wounded, chemical science again claims a share of the glory. The antiseptic treatment of wounds is due solely to the study of the causes which formerly made wounds so fatal. At the present day, if the skilled surgeon can reach the wounded man in time, unless the actual loss of tissue is so great as to bring about a fatal result, the sufferer can be saved. The inflammation and the gangrene which have caused the deaths of so many

soldiers after the battles of the past are now practically unknown in the light of modern chemical surgery. Chemistry has furnished not only the theory on which the antiseptic treatment of wounds is based, but the materials which make it possible.

Finally, it may be said that chemical science stands in a fundamental relation to all the principal arts and industries of the world. It also, by making possible an amelioration of the condition of mankind, has done more probably than any other science for what is known as the "humanities."

In former times a liberal education practically excluded the sciences, chiefly because they were not well known, and because they were not considered necessary to the liberal arts. All this is now changed. While we still value and cultivate the old classical and mathematical learning, we have added to it the training in the sciences, which makes the student at the time of his graduation better fitted for the battle of life. For life at best is but a battle, and war, after all, is the normal condition of mankind. It was the struggle for existence that first brought man from the level of the lower animals to have dominion over them. It was the battle of one tribe with another that enabled the superior race of men to people the earth. It is struggle with his environment that develops the power and the precedence of the successful man. While deploring the horrors of war, the sober student of science must admit that it has its uses. Not only does war and struggle bring power and dominion, but it brings also responsibilities and duties which science will show man how to meet and discharge.

The time has passed when the scientific man is regarded as a recluse. He must take his place in the foremost ranks of progress; he must teach his race their powers and their possibilities; he must show struggling humanity the way to succeed and the way to happiness; he must come into contact with the State; he must show the loftiest patriotism and the greatest willingness to assume and practice his privileges as a citizen. In all these duties the chemist will have his full share and chemical science its proper place.

If we may look for one moment at the future, I think we may safely say that in the days to come the progress of chemistry will enter into more intimate relations with the useful arts and industries, and chemical science become a still greater blessing to mankind.

ELECTRICAL SECTION.

THE SEVENTY-FIFTH ANNIVERSARY OF THE FRANKLIN INSTITUTE FROM AN ELECTRICAL STANDPOINT.

BY EDWIN J. HOUSTON, PH.D.,
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[An address delivered in Convention Hall, National Export Exposition, Tuesday, October 3, 1899, on the Occasion of the Celebration of the Seventy-fifth Anniversary of the Franklin Institute.]

The seventy-five years that mark the life of the Franklin Institute have been fraught with much for the world's weal. During this time great discoveries have been made, and great inventions born, in nearly all departments of physical science, but in none of the sciences have these discoveries or inventions excelled, indeed, I may say, none have equalled, those of electric science and its allied useful arts. Both of these have taken their place in the front rank of progress, and bid fair to continue to outstrip all competitors in their useful gifts to mankind. It is eminently fitting, therefore, that the Electrical Section of the Franklin Institute, representing as it does the electric arts and sciences, shall join with others in celebrating the seventy-fifth anniversary of the Mother Institute, in the Convention Hall of the National Export Exposition of 1899.

The wonderful progress of electric science and its allied useful arts, and the marvellous gifts they have bestowed on the world have not, as in the case of many other physical sciences, been spread equally over an extended period of

time. The last century and a half will take in very nearly all the discoveries and inventions made in electricity; the last century will include by far the most important of these discoveries and inventions; the last half a century, the most valuable and useful, and the last decade and a half, the period of their most extended commercial applications.

Our Institute, founded as it was in 1824, began its existence about the time when electrical activity was markedly increasing, existed during the time of its greatest growth, and still exists at the close of that decade and a half when the commercial applications of electricity have assumed such grand proportions. It is fitting, therefore, that we should inquire both as to how well our Institute, devoted as it is to science and the mechanic or useful arts, has availed itself of the advantages of living in an age of such marked mental activity; and as to what share it has had in the development and application of electrical science.

There is, in every age, a mental horizon which forms the limits of man's actual knowledge. Within this horizon all physical phenomena are readily assignable to their proper causes. Beyond it, other phenomena, discoverable only by the prophetic glance, are too dimly seen to be ascribed to known causes.

In the electrical field this mental horizon was for a long time extremely circumscribed, and even when some progress was made and the horizon extended, obstacles to further progress would loom up, offering apparently insurmountable barriers to further extension. Fortunately, one by one these have been swept away, and the horizon of possible conquest, by unwearying research, has been so greatly extended that, in the public estimation at least, there is little that electric science cannot accomplish.

For thousands of years after his creation man was absolutely blind to the existence of any electric force. Although this mighty power was in operation all around him, in the lightning flash, the Northern light and other physical phenomena, yet he remained practically ignorant of its presence, until Thales, some 600 B.C., discovered the curious properties acquired by a bit of rubbed amber. Even

then the electric horizon long remained relatively limited; for, with the exception of an unimportant observation by Theophrastus, about 321 B.C., it was practically more than 2,000 years before any further advance was made into the great unknown land whose shores were thus first dimly discerned. Not until 1600 A.D. had Gilbert and others discovered that many other substances than amber acquired similar properties when subjected to friction. It is true the Chinese were reputed to have been acquainted with the directive power of the lodestone, and to have applied it to practical ends, as early as 2600 B.C.; it is true that some little extension of magnetic knowledge had occurred during the next thousand years or so, and that some little advance had been made in magnetic science by Hartmann, in 1544, and Norman, in 1576, in the discovery of the dip of the magnetic needle. But the intimate relations existing between electricity and magnetism had not yet been discovered, and, consequently, this knowledge failed to influence the limits of the electric horizon.

Before discussing the part played by our Institute in the world's progress in electric science, let us inquire briefly as to what general principles had been discovered at the time of the birth of the Franklin Institute, in 1824. The extent of this knowledge was very limited. Although from the standpoint of that time—1824—this progress appeared to be wonderfully great, yet, compared with what is now known, it was exceedingly small. Reviewing it with necessary brevity, we find that, in addition to the work of Thales, Theophrastus and Gilbert, already recited, Guericke and Hawksbee had produced, in 1675 and 1700, respectively, fairly good frictional electric machines, and that Newton, in 1675, had discovered that electrification imparted to one side of a glass plate produced electrification on the opposite side. No great discovery had been made, however, until Von Kleist, in 1745, invented the Leyden jar, the early type of electric condenser.

This memorable discovery gave an impetus to the study of electricity, which resulted in a fairly considerable advance. In 1752, Franklin, outrivalling Prometheus, had

robbed Jove of his thunderbolts, and with that national characteristic of turning all knowledge to every-day use, had shortly afterwards constructed the first lightning rod. Then, excepting the discovery made by Æpinus, in 1759, and Canton, in 1760, of the phenomena of pyro-electricity or electrification produced in certain crystalline bodies by unequal heating, a period of comparative rest followed, until Galvani and Volta made their famous discoveries in 1786 and 1796, respectively, the former, in connection with the frog's legs, and the latter with the voltaic cell or battery.

Volta's invention of the voltaic cell gave a marked impetus to electric investigations, by reason of the means thus afforded for readily producing electricity, and the nineteenth century opened auspiciously for electric science. In 1800, Nicholson and Carlisle effected the decomposition of water by a current from a voltaic pile, and, during the same year, Henry of Manchester similarly effected the decomposition of sulphuric and nitric acids. Nor did the advance stop here. In 1807, Davy made his immortal discovery of the compound nature of the alkalies, and produced metallic potassium by electrolysis, and shortly afterwards extended his discovery by demonstrating that all the earths and alkalies also compound substances. In 1807, he publicly demonstrated the illuminating power of the carbon voltaic arc. Finally, in 1820, just four years prior to the birth of our Franklin Institute, Oersted demonstrated the long-suspected relation between electricity and magnetism, and thus swept away another great barrier to advance.

In considering the part played by the Franklin Institute in the world's progress in electricity during the seventy-five years of its existence, it will be impossible, in the brief time allotted to this address, to make any attempt to trace, or even to call attention to, the individual work undertaken by its members, in the domain of either pure or applied electric science. Such work has been both varied and valuable, and will be found in the *Journal of the Franklin Institute*, in the reports of its various committees, in the transactions of learned societies, or in periodical literature. It will, I be-

lieve, be more profitable to employ our time in pointing out the aid our Institute, as a whole, has given, and the contributions she has made, to the general advance in electric science that has taken place during this term. And this, indeed, will be the preferable course, since it is the work of the Institute as a whole, and not of its individual members, in which the public is interested in this, the seventy-fifth year of its existence.

Little did those fourteen men, who, in 1824, organized the Franklin Institute, appreciate the importance of the work they then inaugurated. But, fortunately for its progress, none of the essential requisites for success were absent; the originators were eminently capable men; a great public need existed for the kind of work inaugurated, and its growth was intelligently directed; naturally, therefore, the Institute continued to expand until it assumed the fair proportions it possesses to-day.

There is an enthusiasm begotten of comradeship. When men of similar interests associate themselves together for carrying out any work, that work is not only better carried out as a whole, but the individual workers labor more earnestly and intelligently. But, besides this enthusiasm bred of numbers, each worker, strong in some particular direction, complements or fills out weak points in his fellow-workers. The germs of ideas that might, perchance, have slumbered and died, if selfishly guarded by their originators, blossom out into valuable inventions and discoveries in the enlivening environment of mutual work. It is for the same reason that class study is less fatiguing than individual study, and is, moreover, generally more remunerative, since the errors of others often prevent the continuance of errors in ourselves, and the removal of their difficulties aids in the removal of our own. And even when one has reached the necessity to specialize and pursue his studies alone, it is an advantage to come every now and then into mental contact with others of similar, if not identical, pursuits, not only to have enthusiasm enkindled, but also to readily exchange ideas, solve doubts, suggest lines of research, and encourage each other to further advance in the line of his special studies.

The solitary recluse student, who limits his companionship strictly to his own thoughts, may have the good fortune to avoid errors and make fair advance in his special studies, but that advance will be both surer and more rapid if he will but admit into his mental world either the thoughts of others as expressed in books, or, still better, thoughts fresh from the living lips of those who will afterwards publish them in printed characters. But no matter from whence the student gathers knowledge, its value to mankind may be gauged by the extent to which it is freely given to his fellow-student.

Unfortunately for the world's progress, the characteristics of the miser are not limited to the selfish hoarding of money or other forms of material wealth. The mentally rich are often more reprehensible in hoarding for their exclusive use the little store of knowledge they are foolish enough to believe can be kept exclusively their own; or, if they share such knowledge at all, it is only with little exclusive coteries of their own, for self-glorification. These pigmy mutual admiration societies, whose members are occupied mainly in sounding each his own praises and magnifying his own achievements, aid but little in the general progress of the world. Their mental world, in their belief, is so far uplifted beyond that of the rest of mankind that they are unwilling to have it enter into their lives, and when they have anything worth publishing they too often phrase their discoveries in language unintelligible save to those belonging to their exclusive set.

Associations formed of such men never have and never will develop phenomenal growth. What discoveries are made by any of their members will practically remain a dead letter. It is no excuse to plead that certain lines of study are so abstruse that it is impossible to describe them so as to permit any but those especially skilled even to faintly comprehend, much less to thoroughly grasp them. This is not true. An idea, no matter how complex, if thoroughly understood, is capable of analysis into its component ideas, and these, necessarily elementary, are readily susceptible of being so phrased as to be thor-

oughly grasped by others. He who assumes that his ideas are so far removed from the range of the average intellect that it is useless for him to attempt to appeal to it, and who adopts a mysticism in giving them to the public, not only renders such publications comparatively worthless, but even renders himself liable to the suspicion of but vaguely comprehending the ideas himself.

Some apologists for exclusiveness in scientific research have endeavored to erect a barrier between pure and applied science. While, of course, a distinction necessarily exists between the two, yet the lines of demarcation are by no means sharp, and it is worse than foolish to attempt to keep them apart. Ideas, evolved by the so-called pure scientists, that are incapable of being put to practical use, are shadowy and unsubstantial, and unworthy of being ranked as great ideas.

Another unsound contention of these scientific exclusionists is that the investigator is degraded by actually putting his discoveries into operation for the benefit of his fellow-man. Fortunately for the world, these ideas were not shared by such grand investigators as Morse, Henry or others of their type. Indeed, it is impossible for one to become a great physical investigator who does not continually subject his theoretical deductions to proof by actual trial. It is folly to maintain that he who aims at discovering the laws of nature can make any marked advance without constantly interrogating her by actual experiment. When certain deductions have been made and a generalization reached, if the investigator fails to test the correctness of such investigation by trial, he will, most probably, fail to achieve further advance into the unknown. Conclusions based on laboratory experiments carried on by minute quantities of material and comparatively feeble forces, and those conducted on a commercial scale, are perhaps equally reliable. But no one can deny that the most conclusive test of the correctness of any general physical law is obtained by commercial results rather than those of the laboratory. When a machine embodying the principles of a great invention has been reduced to a drawing, much has been done. But

such a machine cannot be regarded as actually completed until it has been put into gross material and employed in doing actual work.

The magnificent exhibits of the National Export Exposition that are to-day offered for our inspection have been rendered possible only by the carrying out of such lines of action. They are the natural fruits of great ideas embodied in practical working machines or processes.

The Franklin Institute has achieved the marked growth it possesses to-day because its work has possessed the following characteristics, viz.:

(1) Co-operation of work undertaken jointly by men learned in books and men learned in things, a great working brotherhood of theory and practice.

(2) The widest possible publication, in language intelligible to all, of ideas born in its midst, or presented to it for consideration.

(3) Reduction to practice, by subjecting all discoveries and inventions to the test of actual, every-day use, thus carrying out the purpose for which it was incorporated; viz., "The Promotion and Encouragement of Manufacture and the Mechanic and Useful Arts."

For the proper carrying out of these characteristic types of work the Institute has its Regular Monthly Meetings, its valuable Library of Reference, its Memorial Electric Library, its Historical Collections, its various Sections, its Popular Lectures, its Committee on Science and the Arts, its Drawing School, its *Journal of the Franklin Institute*, and last, but by no means least, its Exhibitions or Expositions. It is far from my purpose to refer to these in detail. They are enumerated merely to permit you to readily see how ample are the means the Institute possesses for carrying on its work along the directions already outlined.

The Franklin Institute has carried on important work of the above-named characteristic types in all the physical sciences. But, as representing the Electrical Section, we are to-night mainly interested in electric science, and in this direction the work of the Institute has been of a character of which we may justly be proud. Through all its

characteristic types of work it has contributed freely to advance in electric science, and we might profitably examine in detail contributions of each of these agencies did time permit. Without any desire to belittle the work of the other agencies, I will ask you to examine briefly with me one only of the most conspicuous of these; namely, that of the International Electric Exhibition of 1884, and this, I think, we are justified in doing, since this particular class of work was strictly limited to electrical devices and applications. I might, indeed, well expend the time in considering the work of our Electrical Section, but, since the Exhibition was held at its suggestion, I think a consideration of the work of this exhibition will suffice.

The Electrical Exhibition of 1884 assumed its international character by virtue of an Act of Congress approved February 26, 1883. Like the present National Export Exposition, it was located in West Philadelphia. The conditions were especially favorable for the holding in this country of an exclusively electrical exhibition. The movement favorably attracted the attention of electric scientists and of manufacturers of electrical apparatus in all parts of the world, so that the exhibition contained electrical devices, apparatus and machinery from all parts of the world. Every branch of electric science contributed some exhibits of the most interesting type; namely, working exhibits, interesting as showing the mastery that had been achieved in those branches of electric science that had produced such exhibits, thus putting the electric forces to every-day work.. Besides, there were interesting historical exhibits.

The extent and variety of the different exhibits excited wonderment in the minds of the many visitors. To those unacquainted with electric science, a wonderment that it covered so extended a field; to those fairly acquainted with the achievements of electricity, a wonderment that these achievements so far exceeded in number and variety what they had heretofore credited it with: to those from distant countries, or distant parts of this country, a wonderment that other countries, or other parts of this country, had so far ad-

vanced in their products; to capitalists, a wonderment that so promising and varied a field was offered for profitable investment; to those of an inventive mind, a wonderment that so much room still existed for improvements in existing methods of application, or for work in new directions. The environment of the exhibition favored unusual electrical growth, and subsequent facts amply show that the expectations for such growth were fully realized.

True to its general policy of educating the masses, the authorities of the Franklin Institute proceeded to utilize the occasion to increase the knowledge of its members and visitors. Besides the numerous working exhibits, it collected an admirable historical exhibit, showing the gradual growth of electric apparatus and appliances; it began the collection of a valuable Memorial Electrical Library, it gave to the visitors the names of the different apparatus exhibited, by suitably placed cards, and for further information referred the visitors to printed placards describing the apparatus in detail—placards that were afterwards amplified and issued in the shape of Primers of Electricity; it had courses of public lectures on electrical topics delivered by eminent scientific men, as well as special lectures prepared for the children of the public schools. The exhibition thus became a great school for all sorts, conditions and ages.

During the progress of the exhibition, and called together by reason of its existence, there was assembled a United States Electrical Commission, appointed by the President of the United States under authority of an Act passed by Congress, May, 1884. Under this authority the Commission conducted a National Conference of Electricians, wisely including in its invitations to such conference both men eminent in electrical science and men eminent in the electric arts in this and in other countries.

It was practically in the International Electric Exhibition of the Franklin Institute that the great American Institute of Electrical Engineers had its birth. This great body of eminent electricians that has done so much to create and direct electrical science, both in this country and abroad, may, strictly speaking, be claimed as the child of the Frank-

lin Institute, and, although it is to-day an independent and separate body, yet the friendly relations still existing between the two Institutes may be inferred from the fact that out of the twelve presidents of the American Institute of Electrical Engineers, five have been selected from members of the Franklin Institute, and that during the nearly fifteen years of the existence of the American Institute of Electrical Engineers, eight of these years it has been presided over by a member of the Franklin Institute.

It is difficult to properly estimate the beneficial effects produced on the progress of electric science and its allied useful arts by the mere coming together of such bodies of men in an environment so essentially electric. The wonderful possibilities of electricity, though generally appreciated before the time of the exhibition, were then more clearly seen, and the foundation was laid, certainly in this country, and, most probably, in other countries as well, for that marvellous growth in the commercial applications of electricity which has taken place since the time of the exhibition.

It is far from my desire to claim for this special work of the Franklin Institute that it was the sole influence that determined this subsequent phenomenal growth. It is sufficient if I have shown that it was a directing cause. I certainly feel justified in claiming that never before in the history of this country, and, perhaps, never since, has so much been done to further and foster the electric arts than has been accomplished, both directly and indirectly, by the International Electric Exhibition of 1884, undertaken under the auspices of the Franklin Institute of the State of Pennsylvania.

In inquiring as to the part our Institute has taken in the advances that have been made in electric science during the past seventy-five years, let us briefly consider some of the more important that have been made during this period. We are to-day practically at the beginning of the twentieth century. The seventy-five years we are about considering practically constitute the second, third and last quarters of the nineteenth century. While we can conveniently consider the advances made during this time as the

second, third and last quarters of the nineteenth century, yet it will be advantageous to consider the last quarter, especially with reference to its last decade and a half. In other words, we will divide the three-quarters of a century into two parts, viz., the sixty years prior to 1884, and the fifteen years subsequent to this time. I do this designedly to call your attention to the marked influence the Electrical Exhibition appears to have had on the electrical activity of the entire world; for, we will find that by far the greater bulk of era-making applications reached their most extended commercial extension after 1884.

Of the discoveries made prior to 1884, let us first briefly consider those of the second quarter of the nineteenth century. Oersted's great discovery was almost immediately followed by Ampère's valuable researches, so that, quite naturally, the beginning of this period was noted for the production of the electro-magnet, in substantially its present form, by Sturgeon, in 1825, and by Henry, in 1828. The wonderful extent to which electro-magnets enter into the structure of nearly all modern electric appliances will give some idea of the value of this invention.

But another discovery was made in this quarter of the nineteenth century that was even more important than that of the electro-magnet. I refer to Faraday's immortal discovery, in 1831, of magneto-electric induction. This was the reverse of Oersted's discovery of the production of magnetism from electricity, since it showed how electricity could be produced from magnetism. Faraday demonstrated that when a coiled keeper was suddenly separated from a permanent magnet a spark was produced; that when a permanent bar magnet was suddenly thrust into or withdrawn from a coil of wire, an electric current was set up in the coil, flowing in one direction on the insertion of the magnet, and in the opposite direction on its withdrawal. He also laid the basis for the subsequent invention of a practical dynamo-electric machine by demonstrating that an electric current was produced in a copper disc by rotating it between a pair of magnet poles. All these in 1831.

Faraday's discoveries soon led to the production of fairly

efficient magneto-electric machines, the forerunner of the modern dynamo. Such machines were produced by Dal Negro and Pixii in 1832, by Saxton in 1833, and, subsequently, by Clarke, Ritchie, Jacobi, Sturgeon, Wheatstone, Cooke, Nollet, Von Malderen, and many others. In 1854, Hjorth had discovered, and practically applied, the reaction principle, whereby the currents generated in the armature coils were utilized to strengthen the magnetism of the field, the armature and the field, thus mutually aiding each other until the machine "built up," or became capable of producing its full working current. This principle was independently discovered, either partially or completely by others, especially by Varley, in 1867, and independently by Werner Siemens and by Wheatstone in the same year. Numerous inventions followed, the dynamo of the third quarter of the nineteenth century, reaching its practical culmination in 1870, in the then famous generator of Gramme.

Naturally, the invention of the electric motor also followed Faraday's discovery, so that this important application of electricity also belongs to the second quarter of the nineteenth century. As early as 1831, Henry had suggested and described methods for utilizing electro-magnetism as a motive power. Dal Negro made similar suggestions in 1833, and Jacobi in 1834, and Page in 1850, had produced operative electric motors.

During this period the electrolytic power of the current had been practically applied by Jacobi, who, in 1838, had invented the art of galvanoplasty or electrotyping, whereby the cold casting of the metals might be effected by electrolytic deposition. Elkington and Wright, at a somewhat later date, had made important applications in the same direction. It was also during this period that Ohm, in 1827, made his great generalization concerning the flow of current in the electric circuit.

Another exceedingly important invention of this second quarter of the nineteenth century was that of electro magnetic telegraphy, rendered possible by the production, in 1836, by Daniell of his constant voltaic cell. Consequently, the next year, 1837, was memorable in the annals of tele-

graphy, since during it Morse in America, Steinheil in Munich, and Wheatstone and Cooke in England, produced electro-magnetic telegraphic systems that are substantially similar to those employed to-day. Ever since this date telegraphy flourished, and in 1858, near the beginning of the third quarter of the nineteenth century, Field had accomplished the laying of the first Atlantic cable.

The early part of the third quarter of the nineteenth century was largely occupied in telegraphic matters. The suitability of gutta-percha for the insulation of submarine cables was recognized, the phenomena of electric charge in telegraphic wire carefully studied, the existence of earth currents demonstrated, and various improvements made in telegraphic apparatus. This part of the period culminated in the laying of the Atlantic cable in 1858.

It is interesting to note that this laying of the Atlantic cable, requiring, as it did, the investment of considerable capital, necessitated a more accurate knowledge of electric laws, and so laid the foundations of electric engineering, which may properly date its origin from this time. It is true that frequent efforts had been made before 1858, to introduce the electric light on an extended commercial scale, and that Staite, Petrie, Foucault and many others had produced fairly operative lamps, but the electric current, as furnished by voltaic batteries, was too costly, and these efforts signally failed.

The last quarter of the nineteenth century, as you are all aware, has been a period of marvellous activity in electric science. The excellent dynamos of Gramme, Siemens, Halske, Hopkinson and others in Europe, and of Brush, Weston, Thomson-Houston, Edison, Crocker-Wheeler and others in America, assuring, as they do, the production of cheap current, have rendered possible many extended commercial applications of electricity. For example, another attempt, and this time a successful one, had been made for the extended commercial introduction of electric lighting. Improvements have been made, by the above and others, in generators and lamps for arc and incandescent systems, both by direct and alternating currents; and the

commercial applications of electric lighting that exist to-day, at the close of the last quarter of the nineteenth century, have assumed enormous proportions.

As we have seen, improvements in arc lighting were extended over a comparatively long period of time. The same is true of improvements in incandescent lighting. As early as 1845, King had invented a lamp whose light was due to the electric incandescence of a small pencil or thin plate of carbon in a Torricellian vacuum. Roberts, in 1852, had produced a light by incandescing conductors in a high vacuum. More recently these have been followed, among numerous others, by Lane-Fox, Swan, Maxim, Sawyer-Mann and Edison, especially the latter, who have produced the efficient incandescent lamps of to-day.

Near the beginning of the last quarter of the nineteenth century, in 1876, another era-making application of electricity was accomplished by Bell in the speaking telephone. Bell's invention was an improvement of Reis' prior telephone of 1861. The telephone has, during the latter part of this period, attained a marvellous growth, and is to-day a formidable rival of the ordinary telegraph.

The application of the direct electric current to systems of street-car propulsion is another direction in which enormous progress has been made during the last decade and a half. But probably in no direction has progress been so great as it has in the field of alternating electric currents. Though known long prior to 1875, yet their marked extension commenced at a comparatively recent date. Short as this time has been, it has sufficed to almost create a new science within a science. Electric power transmission on an extensive scale has also been rendered possible by means of alternating-current apparatus.

As to electrical progress since 1884, the time is so recent, a mere decade and a half, that the prominent developments are still fresh in your minds, and might, therefore, be left to what has already been mentioned in connection with the last quarter of the nineteenth century. But so much has been accomplished during this time, and the part our Institute has played, especially in its International Electrical

Exhibition, in determining and shaping this progress has been so important, that we can well devote some time to a consideration of the most important of these developments. If the nineteenth century may be referred to as the Age of Electricity, its last decade and a half may pre-eminently be regarded as the Age of Commercial Electricity, the time during which electric arts have reached their highest development. Indeed, this trait may possibly be the characteristic feature of the twentieth century, so far as electricity is concerned.

Taking up the commercial applications of electricity which have attained phenomenal growth during this time, without strict reference to their chronological order, we will first consider street railways. The replacement of the lumbering stage and omnibus by the horse car, on the tramway or car track, and the partial replacement of the latter by the cable car had already occurred. It was about 1884, that the peculiar fitness of electric traction for the work led to its extensive introduction, and, so rapid has been its adoption since that time, that to-day there is scarcely a horse car to be found in any of our large progressive cities or towns.

Electric traction is pre-eminently one of the commercial applications of electricity that have offered an attractive field for the remunerative investment of a vast amount of capital. Some idea of the extent of this investment may be obtained from the fact that, in the United States alone, the gross receipts of some 222 street railways reached, in a single year (1898), the vast sum of about $128,000,000. Of these 222 roads, some 26 had annual gross receipts of $1,000,000 or over; some 20, annual gross receipts of between $500,000 and $1,000,000; some 58, between $100,000 and $500,000; some 62, between $50,000 and $100,000, and the remainder between $25,000 and $50,000.

Although alternating electric currents, transformers and polyphase motors have been known long prior to 1884, yet their extensive commercial application has been subsequent to that date. The comparative simplicity of the armatures of polyphase motors, their long life under continual use,

and their powerful starting torque give them advantages over continuous-current motors that the commercial world has been prompt to recognize. Moreover, the readiness with which alternating electric currents, in connection with the modern transformer and polyphase motors, lend themselves to the economical transmission of energy over considerable distances, has caused the system to be almost exclusively employed for electric power transmission. In addition to this, we may add the extensive practical application of alternating currents to electric lighting, both arc and incandescent, and to heating, welding and some forms of electric furnaces.

The following estimate as to the total production of alternating-current apparatus in the United States in 1898, will give some idea of the extended use of this type of electric apparatus, viz., total estimated production of alternating-current generators and motors, 120,000 horse-power; of transformers, 750,000 lights capacity, and of meters, 750,000 lights capacity.

Although, as we have seen, the storage battery had its origin in Plantè's secondary battery of 1859, it was not until 1884, that it was capable of extended commercial application. As it exists to-day, its efficiency and length of life under the requirements of actual use have permitted it to come into very extended every-day use, not only for general purposes, but also in electric light and power stations for the purpose of adding to the total output at the time of maximum load. Another use for the storage battery, that promises great developments, is its use for the propulsion of automobiles. The growth of this comparatively new branch of electric science bids fair to assume enormous proportions in the almost immediate future.

Extended commercial applications of the telegraph and the telephone, especially the latter, have been especially marked since 1884. The fundamental apparatus of both the electro-magnetic telegraph and the speaking telephone were invented long prior to this date; the telegraph in 1837, and the telephone in 1861; but while the extended commercial application of the telegraph was made long prior to 1884,

Field having laid the first Atlantic cable in 1854, the extended commercial application of the telephone has been since that time. I will permit you to infer its marvellous growth from the case of a single city, say New York, where, in 1895, there were about 10,000 telephone stations. In August, 1899, there were in the neighborhood of 33,000 stations, thus rather more than trebling the number in less than half a decade. New York City to-day, that is, the old city together with the boroughs of Manhattan and the Bronx, is said to have more telephones than London and Paris together.

The practical commercial application of electro-magnetic waves has been accomplished since 1884. The existence of electro-magnetic waves had been recognized long before this time. As early as 1842, Henry of Princeton observed that steel needles placed in the cellar of his house, were magnetized by a condenser discharge in an upper room. Maxwell, in 1864, had announced his hypothesis as to the practical identity between electro-magnetic radiation and ordinary light, and in 1888, Herz, by employing the principle of resonance, had corroborated Maxwell's hypothesis, showing that electro-magnetic waves possess practically the same velocity as light. Finally, Marconi and others have applied these principles to the transmission of intelligence, and wireless telegraphy is being put to actual use; and although the probabilities of its ever becoming a formidable rival of existing telegraphic systems are somewhat remote, yet it possesses great future possibilities.

The so-called X-rays form, most probably, another variety of electro-magnetic waves that has come into extended commercial use since 1884. Their peculiar behavior as regards many substances opaque to ordinary light (itself a form of electro-magnetic radiation) has rendered them of great practical value in connection with photography, for accurately locating the position of certain foreign substances in the human body, as well as indicating abnormal conditions of its tissues, organs, etc. The Wehnelt interrupter, which has been of so great service in connection with the induction apparatus used in X-ray work, has also been introduced since 1884.

Electric lighting, both arc and incandescent, has shown an enormous increase in actual use since 1884. The number of electric lighting stations now existing in the United States is by no means limited to the number of cities and towns in this country. In nearly all large cities there are separate stations provided for different localities. Moreover, the number of isolated plants in all our large cities and towns is considerable, some of which, in the case of tall office buildings, are almost sufficiently large to equal in their output that of moderately large central stations. For example, in the city of Boston there are, according to a recent report, no less than twenty-nine generating stations and 195 isolated plants. The dynamos in operation have a total capacity of 424,443 incandescent lamps and 10,094 arc lamps, which, including some 7,070 electric motors, require some 90,382 horse-power of boilers and 66,774 horse-power of engines.

The part which electricity, mainly since 1884, has come to play in our lives in great cities is manifold. We light our streets, our public buildings and our houses with it, drive our street cars, transmit messages by telegraph and telephone, operate annunciators, protect our buildings by fire and burglar alarms, drive motors, rotate fans, bring cheap power from distant waterfalls to our doors, install electricity for varied purposes on our war vessels, and employ it in many other ways, which will doubtless suggest themselves to you.

This extended commercial use of current calls for the manufacture of much apparatus. Looking over the annual report of a single large company in this country, we find that for the year ending January 31, 1899, the total sales, as billed to customers, amounted to more than $17,260,000, and this, good, profitable business, the calculated direct profits amounting to more than $2,500,000. Some idea of the business done by the company in electric lighting may be inferred from the fact that during this term the orders for incandescent electric lamps reached 8,400,000 lamps!

The manifold uses of electricity to-day in our modern cities mean the employment of a vast number of electric

wires and conduits, both overhead and underground. Take, for example, the city of Boston. There are, in this city, according to a recent report, of underground wires alone, 726,997 feet of conduit; 3,469,011 feet of duct; 5,427,482 feet of cable; 167,751,793 feet of single conductor in cables.

The enormous demand for electric apparatus has not been without its effect on the price of copper, which has advanced materially during the past five years, rivalling even the increase in the price of zinc, lead and iron.

Such is the record of the seventy-five years during which the Franklin Institute has existed. That it has exerted a marked influence on the extension and application of electricity, not only, as I have endeavored to point out, by its great International Electrical Exhibition of 1884, but also through the many other kinds of work by which it endeavors to extend electric science and ensure practical applications of the same, I believe none will question. Regarding to-night the growth attained by electric science during the nineteenth century, we may well exclaim with Morse, "What hath God wrought?"

THE INFLUENCE OF TECHNICAL SOCIETIES IN PROMOTING THE PROGRESS OF THE ARTS.

By Ralph W. Pope,
Secretary of the American Institute of Electrical Engineers.

[An address delivered in Convention Hall, National Export Exposition, Tuesday, October 3d, on the Occasion of the Celebration of the Seventy-fifth Anniversary of the Franklin Institute.]

When we consider the vast strides made during the century in practically every branch of applied science, or even the advances made within the memory of the youngest among us, it is not now difficult to realize that seventy-five years ago there existed a field for the Franklin Institute.

That it survived, and is now active along the lines projected by its founders, proves, beyond question, the wisdom

of those whose memories we unite in honoring to-day. A record of seventy-five years devoted to the encouragement of art and science is most enviable, and whatever may happen, no break in its continuous career should ever be permitted.

Here has been maintained, through peace and war, through prosperity and adversity, a forum where every struggling scientist and every hopeful inventor might meet with the encouragement that stimulates, or that kindly criticism which frequently leads to well-merited success.

It has been the good fortune of the Franklin Institute to watch beside the cradle of the infant steam: to observe the gradual development of this mighty force, until upon its foundation there has been erected the new and gigantic electrical industry which through ignorance is frequently considered its rival and possible successor. The builder of the steam engine has seen no wave of prosperity which will be so enduring and so satisfactory as that which has followed in the wake of the electric generator and motor.

While the utilization of water power for the generation of electricity is important, nature has arbitrarily confined this practice to a comparatively few and limited districts, so that to-day, and, so far as we can predict, in the future as well, the steam engine as a prime mover is without a rival. The power having been developed, what may we not accomplish through that unequalled distributing agency, the electric current?

Just as the steam railroad had entered upon its useful career, the world was startled by the successful invention of the electric telegraph, the first example of instantaneous transmission of power to a distant point. Still mankind had lived and multiplied, nations had arisen, cities had been founded and fallen into decay, great battles had been fought, literature and the arts had flourished. The steam engine, however, was unknown, and the telegraph was but a dream.

Even to-day, surrounded, as we are supposed to be, with every possible convenience and luxury, men and women may be found living happy and contented lives who have

never sent a telegram, nor seen an electric car. Consider Alaska, until recently without a railroad or a telegraph, where only hardship, famine, disease and possibly death were reasonably certain; where men have fallen in exhaustion overladen with gold, which brought no food where food did not exist. But men with stout hearts and sturdy muscles have left comfortable homes and lifelong friends to grapple with cold and hunger in order to wrest from nature's secret storehouses the golden nuggets which have been hidden for ages in that hitherto almost inaccessible spot.

We have assembled to-day, however, to eulogize the influence of science upon the advance of civilization. We are here to assert that the world is growing better, even as we believe it is growing more comfortable. Brief as may be our pilgrimage, we live longer, or rather, as we journey through life, our experience is greater. The world's history, thanks to the press and the telegraph, is spread before us each day as important events occur. The thread of sympathy with the distressed entwines the hearts of every nation, and again, in the words of the Psalmist: "Let the earth rejoice," for is it not known throughout all lands that Dewey has received the grandest welcome of ancient or modern times?

Even this great outburst of patriotic enthusiasm is a tribute to scientific research. Without the aid of steam or electricity the concentration, within so short a space of time, of such a multitude from all portions of the country upon Manhattan Island would have been an impossibility.

Step by step, during this wonderful nineteenth century, we have watched the growth of these marvellous achievements until we have been educated to the belief that there is practically no limit to the stride of invention. When we consider the perfection of modern mechanical methods, however, the results obtained in early days should excite our admiration.

Fifty years ago the steam locomotive had a speed record of a mile in a minute, and the general improvement in schedule time since that period has been largely due to a

more perfect track and longer runs rather than to any radical change in the original machine. With the same machinery used fifty years ago the skilled Morse telegrapher could do as rapid work as he can to-day.

In both cases the original idea appears to us now as exceedingly simple. Subsequent perfection in details has been a process of evolution. During all this time a small army of inventors had grappled with the problem of a type-setting machine, and not until within the last ten years has success been attained. The germ of a great invention is a tender plant. It must be nurtured with extreme care. It is for the encouragement of these early steps in the advancement of an art that this institution exists.

Once success in an art is attained, popular enthusiasm will soon place it beyond the reach of adversity. Too frequently the original inventor, and even the sanguine financial promoter, fail to reap their just reward, but the idea lives, and the people are benefited by the improvement.

Notwithstanding the important bearing which science and mechanics have upon our national progress as well as our personal comfort and satisfaction, your attention is directed to an apparent omission in our educational system. It is quite certain that scientific and engineering societies would be more generally appreciated and more heartily supported, if students were more thoroughly trained at an early age in elementary physics. They should also have an opportunity for practical work in wood and metal with good tools. If they have no inclination toward work of that character, the experience will do them no harm, while in the majority of cases the knowledge thus gained will be of great use to them later in life.

Within the past few years more attention has been given to manual training, but there are still, no doubt, thousands of schools in the country where there is no attempt to master even the simplest scientific facts.

As I travel daily between New York and my home at Elizabeth, the Staten Island shore is plainly visible. Years ago a vessel laden with oil took fire and was beached at the northern end of the island. The oil continued to burn for

a day or two, and the novel sight naturally attracted the attention of the passengers. Directly in front of me two intelligent-looking gentlemen laid aside their morning papers for a moment and began talking about the fire. One of them said he supposed that what they saw was the burning oil floating on the water. "I know oil will float on the water," said his companion, "but I'm not sure whether it will float when it is in barrels." "Neither am I," was the reply. Here were two men, either of whom knew that oil would float on water, and either of whom was probably certain that a barrel would float, but whether the two combined would float or sink was beyond their comprehension.

It is not necessary that we should know what electricity is, or what gravitation is, or account for the existence of what is known as permanent magnetism. We can, however, readily master certain laws based on scientific facts. We can assure ourselves that, under certain conditions, certain results will be accomplished. There is no reason why these facts should not be thoroughly grasped in childhood. There are no toys so interesting to the young as what are known as scientific toys, and if parents are neither willing nor capable of teaching their children these important truths, we should see that they are generally taught in school. The prevailing ignorance in such matters is responsible for the existence of a class of alleged inventors who devise schemes for obtaining money under false pretences. Most of us are familiar with examples of this fraudulent practice, and Philadelphia has been a favorite field of operation. The notoriety attained by such impostors has reacted upon honest inventors, who frequently lack capital to develop their ideas. There is but one safe course for an innocent but honest investor. He should seek the advice of an experienced and competent expert familiar with the field which is to offer a market for the invention. If he is not financially able to pay for such an opinion, then he is not in a position to take the risk of a doubtful investment.

It is too frequently the case that the investment is made first, and the expert called in after thousands of dollars have

been squandered. There is always an air of suspicion hanging about these questionable enterprises. Some vital link is a profound secret. There is a mysterious chemical compound or some unaccountable manifestation of force casually referred to by the exploiter that should place every investigator on his guard. It is not necessary that an expert should be expected to explain a manifestation when he is morally certain that something is hidden from him.

On the other hand, it is not always well to place too much confidence in the statements of the really honest inventor. His mind may be biased by his enthusiasm, and without intent to mislead, he may neglect to call attention to certain facts which would detract from the usefulness of his improvement.

Having guarded all these points, however, there is still another test to which an important invention may be subjected. Let it be exhibited and accurately described in open meeting before such a society as the Franklin Institute or the American Institute of Electrical Engineers. When the subject is thrown open for discussion, the demonstrator must have his wits about him. He will find that flaws exist which he never dreamed of. He will learn that even if his apparatus works, there may be a dozen reasons given why it ought not to work. He will be surprised to find that the cost will be so much greater than under existing conditions, that no one will have anything to do with it. He should not be discouraged by these slighting remarks. There are always people who think that anything new is not good, and anything good is not new. If his machine or process works, he can disregard the reasons why it should not. If it is a decided improvement, he should remember that good things are frequently expensive. People do not continually eat "pork and beans" because experts say the dish is nutritious and cheap.

It is not my intention to ridicule free discussion, but rather to call attention to its value in bringing to light all the bad as well as the good features of an invention, or the merits and demerits of a process, or the strong and weak points of a line of practice.

There is another great influence exercised by a society of this character, which, unfortunately, we cannot accurately determine. Experience shows, however, that it must exist. During the interchange of ideas, the brain is stimulated to unusual activity along the lines made prominent by the subject under discussion. New thoughts are developed and improvements are suggested. For the moment a participant becomes a worker in possibly a virgin field. He groups the facts gleaned from his experience, and, as a result, another improvement comes to light. The suggestion may be thrown out as a free gift, or it may be withheld for the time being, and eventually brought out in independent form.

Frequently men of high professional standing who cannot be induced to write a paper, or an article, will gladly participate in a discussion which has awakened their interest, and the world's record is enriched by thoughts which might otherwise never have been revealed.

Notwithstanding the classification or specialization that has gradually developed in the general field of engineering, the training which each individual receives leads him to gradually absorb a great deal of information which is not in his own line. Thus an electrical engineer should be, and frequently is, well versed in mechanical engineering. The civil engineer and the mining engineer should be familiar with both mechanical and electrical engineering in order to determine the best application of power under existing conditions. Although all citizens should be interested in the construction of public works in the best possible manner, in order to give really intelligent opinions, they should be trained engineers. There is a good reason for this, as years of study and experience are required to enable a man to intelligently select from different materials that which is best suited for a contemplated improvement. Take the question of pavements, for instance. In some cases the residents along a street are called upon to decide what kind of a pavement they prefer. Various conditions must be met, and each person is expected to contribute his own views to the discussion. He may want Telford because it is the cheapest, or Belgian because it is

most durable, or asphalt because it is noiseless, or brick because he has heard that it was better taking all things into consideration. It is the life-work of an engineer to study and compare all these conditions, and it is his constant aim to get the very best results at the least possible expense. Professional pride will not permit him to authorize improper materials, for his reputation is based upon the character of his work.

If the engineer was more freely consulted in even what are considered the minor details of all public work, better results would be obtained. An eminent New Jersey judge recently made the statement that, during thirty years' experience, while every contractor for public work had been required to file a bond of guaranty for the faithful execution of his agreement in accordance with specifications, there had been no instance of suit being brought for recovery of damages on account of defective construction. This does not prove that the work has always been faithfully done, but rather that lax inspection under existing political methods has failed to protect the interests of the public.

One of the most important qualifications of a society like this is the continuity of its work. Its individual members are mortal, but, so far as we can predict, there is no reason why the organization itself should not be perpetual.

Its success is based upon scientific facts. Its printed records now form, and will continue to form hereafter, a growing history of mechanical and scientific development. The compiling of history, interesting and important as it may be, does not appeal to the general public. It is the activity of the living present which attracts the attention of the multitude.

Phenomenal scientific discoveries, or epoch-making inventions, are exceedingly rare. Year after year a society must plod along, satisfied with thoroughly investigating each progressive step, and aiding in that gradual improvement which eventually brings about those grand results which are appreciated only when we halt for a moment, and review the progress of a decade or a century.

There is one exceedingly important duty voluntarily undertaken by societies which is of immense economic value. This is the introduction of standard practice in the particular field in which they are interested. Various individuals and manufacturing concerns, working along their own lines, gradually introduce products or methods, until with the growth of an industry there are certain differences established that finally become a well-recognized evil for which there is no apparent remedy. Finally, this state of affairs is seen to obstruct the attainment of the best results, or is even wasteful, by requiring the unnecessary expenditure of time, capital and labor. It is brought to the attention of a technical society through proper channels, and committees of experts are appointed, who industriously undertake to remedy or mitigate the evil. So thoroughly entrenched are existing practices, that the work of reform is beset with difficulties. In spite of these adverse conditions the project is carried through, and in some cases has received governmental sanction. Various organizations have taken up questions of this kind, and, while it is hardly possible to determine the exact benefits thus attained, there can be no doubt that great good has been accomplished. Among the examples that may be cited are "Standard Screw Threads," by the Franklin Institute; "Standard Boiler Tests," by the American Society of Mechanical Engineers; "Standard Steel Rail Sections," by the American Society of Civil Engineers, and, within the present year, the "Standardization of Electric Generators, Motors and Transformers," by the American Institute of Electrical Engineers.

It is gratifying to know that men of affairs, whose time is valuable, will so heartily devote themselves to the solution of the perplexing problems arising in the course of establishing standards of such a character that they will meet with the approbation of those who are expected to conform with them.

It should also be remembered that to the Franklin Institute should be given the credit for the organization under government auspices of the National Conference of Elec-

tricians in connection with the Electrical Exhibition at Philadelphia in 1884. The organization of the International Electrical Congress of 1893 was undertaken by the American Institute of Electrical Engineers, and the publication of its proceedings was carried out by the latter when otherwise its records would have been hidden from the world. This Congress established standards of nomenclature and of dynamic values and units which have been generally approved and recognized. There can be no doubt as to the public benefit arising from the existence of these organizations, but the carrying on of such work involves considerable expense, and this falls upon the members, many of whom feel that they receive no equivalent. This may be true within the limits of their past experience, but no one can tell what the future may bring forth. An item from a single contribution to the Transactions frequently is of more value to an engineer than the cost of many years of dues.

The first thing a young man should do in entering upon his professional career is to become a member of a society where he will come in personal contact with his fellow-workers. He should take a sufficiently active interest to show that he is not only capable, but ready to do his part in advancing the general welfare. He will soon find that it is not only a satisfaction to be identified with the organized membership, but that it will also be a direct advantage to him in many ways. Although the membership of a national society must necessarily be composed of those who are rivals in business or in the employ of competing companies, all antagonisms due to these conditions are laid aside in striving for the general progress of the profession. Institutions of this character enjoy a high standing in the community, and such work as appeals to public recognition is fully appreciated. There is still lacking, however, that continued interest in their routine work which its importance demands. While universities and colleges are handsomely endowed and suitable buildings erected for their use as memorial gifts, societies must levy on their supporting members to build or purchase houses, and ob-

tain their libraries in a similar manner, which are, nevertheless, frequently thrown open for public use.

Experience has shown that one of the most serious problems confronting a society of this character is the privilege of a proper meeting place, or, in other words, a suitable home. That the importance of such a building is fully recognized is shown by the efforts that are made to purchase one as soon as the revenue of a society becomes sufficient to warrant the expense. This is not an insurmountable difficulty in the case of national societies. The establishing of a home and library in the city which is selected for headquarters does not, however, meet the requirements of the entire country. In every city there is a sufficient number of men interested in scientific and engineering questions to form local societies or clubs which would be of great public value in the administration, for instance, of municipal affairs. It is in such towns that the lack of a suitable meeting place or the expense of maintaining one interferes with the formation of technical organizations. Their existence is not considered a public necessity, yet, when important municipal improvements are projected, there could be no more satisfactory discussion of the problems to be considered than would be elicited from a body of this kind. It would differ from a town meeting in several important respects. Each member would be trained to view the questions from a scientific standpoint. He would not be influenced by the political aspects of the case. He would base his opinions on the experience of others, and he would be familiar with the record of that experience or he would know at once where he could refer to it.

Having been assigned the duty of pointing out the advantages occurring from the existence of such organizations as the Franklin Institute, whose seventy-fifth anniversary we have gathered to celebrate, I have gone a little further and intimated that they might be still more useful if the people generally were closer in touch with their proceedings. They are really supplemental to our educational system. The fact is generally recognized that no matter how high may be the standing of a college graduate, his education in the

school of experience ends only with his life. It is through these societies that the results of personal professional efforts are gathered and recorded. His thoughts are brightened, his best work is studied and appreciated by his colleagues. He is stimulated by healthy rivalry to do his best, and to honor the achievements of others.

We need have no apprehension as to the future of our great technical societies. There are the best of reasons for their continued existence and their healthy growth. Their foundations are deeply embedded and beyond the reach of those discordant elements which frequently revolutionize governments, divide our churches and overthrow the greatest financial undertakings.

THE FRANKLIN INSTITUTE.

Stated Meeting, Wednesday, February 15, 1899.

THE PHOTOMETRY OF INCANDESCENT LAMPS.

A SPECIAL PLAN FOR READILY PROCURING RESULTS, AND THE APPARATUS NECESSARY FOR THE PURPOSE.

BY PROF. ARTHUR J. ROWLAND,
Member of the Institute.

In the industrial photometry of incandescent lamps, one of two things is always the object of measurement, *i. e.*, the candle-power which an incandescent lamp has at any applied E.M.F., or the E.M.F. which should be applied to produce a given candle-power. The first is the one with which users of lamps have to do; the last is a determination which the manufacturer of incandescent lamps has to make for his whole product. Strange as it may seem, the last is much the harder to obtain if ordinary photometric methods are used.

There are many sorts of photometers and many methods of using them. What I shall say will have reference to but

one sort, a Bunsen photometer, and to a certain plan of using one which makes it especially easy to work with.

A Bunsen photometer is a familiar instrument. In its simplest form it consists of a graduated bar, at the ends of which are located the lights to be compared, one of them being of known candle-power. Along the bar one moves the car, which holds, in a plane perpendicular to a line joining the lights in question, a paper with a grease spot on it. When a position is reached where the spot cannot be distinguished from the surrounding paper, one knows that the illumination of both sides of the sheet is alike; that is, since the illumination of a surface falls off with the square of the distance from the light source, by taking ratios of distances to lights from the car position squared, one has obtained the ratio of the candle-power of the lights.

In practice one has many obstacles to overcome in getting this simple result. In matters photometric there are such as:

(*a*) Too large a ratio between the candle-power of the light measured and that of the standard light. This causes a slight inaccuracy in the setting of the car to make a very disproportionate inaccuracy in the resulting candle-power calculated.

(*b*) A difference in the color of the lights which are being compared. This makes it impossible to find a place along the bar where the grease spot disappears.

(*c*) Reflection from surrounding objects. A distortion of the illumination of the paper in the car results, so no *true* ratio can be found.

(*d*) A difference in the quality of the sides of the paper with the grease spot on it. If the paper be turned side for side, quite a different setting of the car for "equal illumination" will be found.

(*e*) A difference in eye-sensitiveness. If one stood on the other side of the bar a different determination would have been had.

(*f*) A difference in mirrors used to enable one to see both sides of the paper at the same time, and so distortions, similar to those last mentioned, are produced.

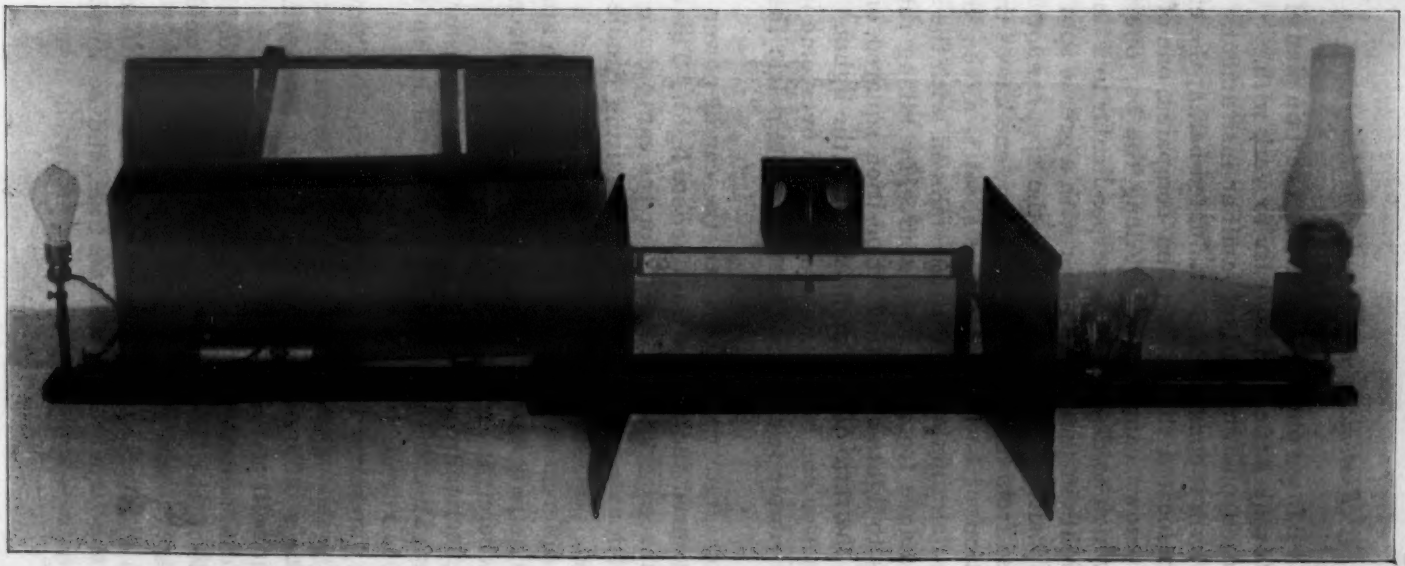


FIG. 1.—The photometer set up ready for use.

In matters of manipulation there is the difficulty in keeping the E.M.F. on the lamps steady; in adjusting the E.M.F. within very close limits; in knowing the exact E.M.F. sending current through the lamp, due to the inaccuracy of voltmeters which have not been especially calibrated for the work. Any of these not right and errors in the results are found, so they become utterly unsatisfactory and unreliable. An inexperience in making readings or poor choice of conditions causes results to be procured which are equally valueless.

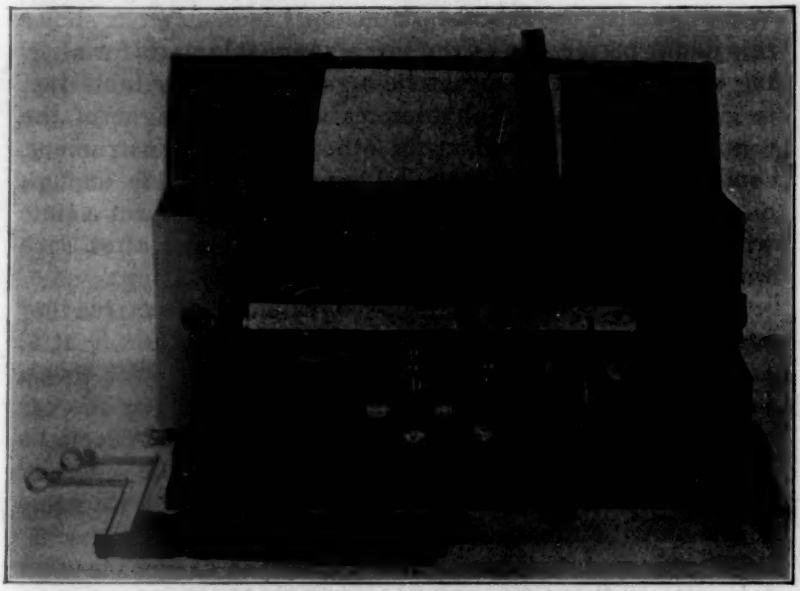


FIG. 2.—The photometer folded and ready to put into its carrying case.

In getting results in the usual way one has to labor through the tedious process of taking ratios of distances which must be squared, and must take enough readings to eliminate errors already mentioned by taking averages of candle-powers determined from a number of car settings.

So many of the difficulties are met and mastered in a portable photometer which has been loaned me by the Electric Motor and Equipment Company, Newark, N. J.,

that I will use it as a text in considering the special method of measurement I want to describe. In this photometer a grease spot car is used, and the standard is an 8 candle-power oil lamp, which practice shows to be of more than required constancy over a period of twenty minutes or more at a time.

Fig. 1 shows this photometer ready for use. The different parts may be described by reference to letters placed directly below them in the cut. At *A* is put the incandescent lamp whose candle-power is to be determined. Provision is made on each photometer for lamps having Edison, Westinghouse or Thomson-Houston bases. *Fig. 2* shows this detail better, one of the interchangeable parts for altering the style of the socket being shown on the table just in front of the packed photometer and to the right of the center of the cut. At *B*, at the other end of the instrument, some five feet from *A*, is the oil lamp. This holds enough oil to burn for four hours in use, and for an hour at a time with practically no change in its candle-power after once warming up and being set.

Since the standard is of fixed value, a direct reading scale can be used. It is shown directly below the car at *C*, and is marked off on celluloid from 7 candle-power to 34, marks being made for each half candle-power. In the car one can see the screen with grease spot, and the reflections of the two sides of the paper in the mirrors. The index for reading candle-power at any car setting shows on the scale just under the grease spot.

The screens, *F F*, are to shield the eyes of the observer from direct light from either source. His eyes must be protected thus so they may be adapted to distinguish small differences in tint of spot and field as he views the reflections in the mirrors. This arrangement makes "taking readings" much less fatiguing than the common and older plan of using an eye screen fast to the car, such as is used with fluoroscopes.

At *E* is a rack to hold the standard lights. They are here out of the way, and yet conveniently placed to carry about or use.

A very refined adjustment of the E.M.F. on the lamp terminals is provided for by the rheostat shown at *D*. This is a solenoid of resistance wire along which a contact piece is arranged to be moved, so varying the E.M.F. on a 16 candle-power lamp through a range of 15 or 20 volts by steps so small as not possible to detect with a first-class voltmeter. Thus one has at command the adjustment of the E.M.F. on the lamp under test to the exact value required, and a cause of errors of considerable magnitude is eliminated. At its marked E.M.F. a 16 candle-power 110 volt lamp will vary in candle-power as much as 6½ per cent. for a 1 per cent. change in E.M.F. applied, it must be remembered.

Between the incandescent lamp and rheostat there are some simple switching devices provided, and the connecting cords to use at them to bring current to the photometer and to connect voltmeter, ammeter, wattmeter or all of them at once to the circuit, as one chooses.

The 8 candle-power oil lamp is set to the value it must keep through a set of readings in a fashion which at once eliminates nearly all the difficulties in making satisfactory photometer measurements, which I have mentioned. The method of proceeding to a candle-power measurement is as follows: The oil lamp is lighted and warmed up. A standard incandescent lamp at an E.M.F. about like that on the circuit to be used is put in its "standard position" (that for which its candle-power is known), and its terminal difference of potential made that demanded on its label. It is now 16 candle-power from a direction down the photometer bar. The car is next set at the 16 candle-power mark and the light from the oil lamp adjusted until the grease spot disappears. The standard incandescent lamp is next removed and others, whose candle-power it is required to know, put in its place, one after the other, the car being shifted to a point where the grease spot disappears for each one, and their candle-power thus read directly. After a little practice one can make such readings on a 16 candle-power lamp so that the widest range of values determined will not be more than $\frac{4}{10}$ of a candle-power. And if all are

averaged, no reading differs from this value by more than $\frac{2}{10}$ of a candle-power. In other words, an accuracy in a single reading will be within $1\frac{1}{2}$ per cent. of the truth. This is a very satisfactory result for a determination of candle-power on a commercial photometer. It is to be understood as applying to readings made at different times upon the same lamp.

Or, for other purposes, the car is left at 16 candle-power, for example, and the E.M.F. on the lamp varied until the spot is gone. The determination of this last can be made by a practised observer with quite remarkable accuracy, considering the shortness of the bar.

The oil-lamp standard can be checked at any instant by a return to the incandescent standard at the other end of the bar, setting the index on the car at the 16 candle-power mark and observing whether the grease spot is now invisible, as it should be.

Without going into a detailed explanation, one has, by this method, done away with all difficulty due to reflection, difference in quality of the sides of the greased paper, difference of eye sensitiveness, etc., and done away with them all to such an extent that a real dark room is not required to get satisfactory results. If only the light is not shining in the observer's eyes, a room not so dark but that common newspaper print can be read in it is satisfactory for ordinary work. By putting the real standard at the same end as the lamp whose candle-power is measured, all distortions come into every measurement in exactly the same way, and so are negligible. I am not informed whether or not this plan of working is original with the company above named, but it is certainly a plan of greatest possible value to any one who has many measurements of candle-power to make, and wants them procured in as rapid and yet accurate a way as possible.

It will be seen that really the candle-power of the oil lamp never becomes known. It is simply a steady light, the value in candle-power of which need not concern one.

The oil-lamp flame is not noticeably different in color from many incandescent lamp filaments, especially if the

incandescent lamps are not perfectly new and burning at high incandescence; and, by using it, rather than a second incandescent lamp, one does away with the necessity for a second voltmeter and its separate and accurate calibration.

It cannot be denied that, if there are incandescent lamps at both ends of the bar, having the same efficiency and candle-power, any fluctuations of E.M.F. on the circuit after that on both lamps has been set will not interfere with the candle-power determinations, since the ratio of candle-powers will keep the same. But any advantage so obtained is more than offset in most commercial work by the necessity of having voltmeters for both lamps, and accurate ones, too.

Since the photometer I am using to illustrate these remarks is a portable one, it lacks certain accessories, like a rotating socket, by the use of which the mean horizontal or rated candle-power becomes known at once.

Fig. 2 shows the instrument packed and ready to be put in its carrying case, shown in the background. There is no question as to the exceeding portability of the instrument, not only because it can be used without a dark room, but also because it can be put together so compactly to carry around.

Considering the purpose for which it was designed, therefore one can forgive the lack of a rotating socket.

I have described the instrument, not because it is a perfect one for *all* requirements of up-to-date photometry, but because it seems to me, a disinterested party, to embody very many points which must make a commercial photometer a satisfactory instrument, and so to be worthy of presentation to the members of the Institute.

On the GRAPHICAL PRESENTATION of STATISTICS.

By Lewis M. Haupt,
Member of the Institute.

While statistics are said to be uninteresting, they are, nevertheless, invaluable as indices to the progressive man of affairs who would keep in touch with the industrial development of his own or other countries. But masses of figures arranged in tabular form are confusing and often misleading, without great labor in classifying or in reducing them to units of comparison. Frequently only total quantities or values are given of imports, exports, output, product or prices, rendering a large amount of calculation necessary before unit values or percentages for various years, periods or commodities may be secured, and without which no comparison is possible.

To show the growth of any particular industry, it is evident that at least two factors must be represented, viz., time and quantity, or time and value. When all three are known, and the totals only are given, they must be reduced to the value of the unit for each time stated, to determine the actual returns. Since quantity may be expressed in many different denominations, as in pounds, tons, yards, bushels, bales, barrels, stones, cords, etc., they must also be brought to a common basis for comparison.

To avoid many of these difficulties, the practice of representing statistics by the aid of diagrams, plain, colored or shaded in conventional symbols, is rapidly growing in favor, but the existing conventions possess defects which render them almost useless as bases of comparison for commercial purposes, unless accompanied by abstract figures, in which case the former objections are not eliminated.

THE EXISTING DEFECTS.

For example, in comparing quantities of any particular kind, as of population, a column is built up of colored blocks having three dimensions, requiring the eye to

compare these volumes with one another. Often they are not even similar volumes, so that the cubes of their edges cannot be used for the purpose intended, and unless the figures be branded on the blocks, no idea can be obtained of even their relative volumes. In many other cases areas of various forms and sizes are used, especially rectangles and circles, but frequently sectors are employed in circles of different diameters, to indicate growth from year to year. Here, again, figures of two dimensions are therefore erroneously used to represent quantities of only one dimension. It is true that the circumference of the circle may be subdivided into arcs, representing proportional parts or percentages of traffic or product, but unless the ratios are indicated in the degrees of the central angle, or the relative lengths of arc, the sectors possess but little actual value for comparison.

Even where statistics are represented in columnar form, laid off on both sides of a central axis, the curve of increase is bisected, one-half of it being on either side of the axis, and, therefore, the correct curve is not shown on the diagram, but must be deduced from it by a mental operation.

Again, it frequently happens that the intervals of time when the record is made are quite variable, so that without interpolation a correct idea of the form of the curve cannot be obtained even with the abstract figures stated. Certainly the rectangles drawn to scale, unless taken in connection with their time intervals, become quite misleading. The absence of uniform scales, and the omission of any reference thereto, results in representing the parts as sometimes greater than the whole, a manifest absurdity.

These and many other incongruities arise from the promiscuous pictorial methods in vogue intended to educate the mind by unscientific, popular methods, resulting in "confusion worse confounded."

SUGGESTIONS FOR GENERAL USE.

All quantities, of whatever denomination, kind or extent, which are capable of being measured, may be expressed in abstract figures, and such figures may always be repre-

sented by linear distances drawn to scale by taking any number of such parts as a unit. As the number representing the quantity or price may vary from time to time, so the lengths of the lines will vary for the corresponding times, and these lines may, therefore, be compared, and the ratio of any one to any other be determined by projecting them upon a sheet of cross-section paper, starting always from a straight line or edge.

Thus, if the law of the increment of any variable quantity is to be represented, the times at which the variations occur may be laid off along a straight line, while the actual value of the variation may be platted in a series of lines at right angles to the first, constituting a system of rectilinear coördinates, of which the times may be the abscissa (x) and the quantities the ordinates (y). By drawing a line through the extremity of the ordinates, the curve showing the change in value of the quantity is at once revealed.

If the increments for equal times are equal, the curve will become a right line, and a prediction can safely be made as to future probabilities. If it bend upward, the increments are increasing; if downward, decreasing. They may oscillate violently, indicating lack of stability or great fluctuations in value, generally traced to some external cause affecting the value of the commodity used in exchanges, as a plethoric or stringent money market, abundance or paucity of crops, etc.

TO ILLUSTRATE DEVELOPMENTS.

The resulting diagrams, if platted as indicated above, will give a simple, accurate exhibit of the conditions existing at any particular date, whence they may readily be connected with correlative events, and the relation between cause and effect be largely determined with accuracy. As population is the basis for, and principal element in, industrial development, and as it is important to determine the probable increase as affecting questions of consumption or traffic, it may be instructive to illustrate the above method by platting the curve of the growth of population during the past century in the United States. Thus, on the diagram, it will

be seen that the axis of X is horizontal, having a scale of ten years to 1 inch, while that of Y is vertical, having a scale of 10,000,000 to an inch. (See *Plate I.*)

Taking the origin of coördinates at O, and the data from the census reports for each decade, beginning with 1790, it will be seen that the curve at first departs but slightly from the horizontal axis, but gradually increases its flexure upwards and must, in course of time, approach a tangent to the vertical, becoming, in short, an asymptote—this, too, notwithstanding the fact that the *percentage* of increase decreases from the beginning to the end of the century.

It is thus shown at once that the increment is not a simple ratio, as in an arithmetical progression, but is being compounded each decade. Hence it is that the population under normal conditions increases more rapidly each decade, although the percentage may decrease. Between 1790 and 1890, for instance, the population increased 1,491 per cent., or 14·91 per cent. on an average each year, if computed as simple interest upon the original principal. Yet the rate each decade before the civil war was varied from 33 to 36 per cent., or only $3\frac{1}{3}$ to $3\frac{7}{8}$ per cent. per annum.

During the war decade it was only 23 per cent., increasing to 30, and again decreasing during the last decade to 25 per cent.

The actual increments of population, however, were nearly 12,500,000 in 1880-90, as compared with less than 2,000,000 in 1800–10, when it was 36 per cent. of the whole.

What this rapid or compound increment portends in the near future for the trade prestige and influence of this nation may be more clearly understood by extending the curve at the constant ratio of that of the past decade, namely, 25 per cent., from which it appears that the population of 1890 will have doubled itself by 1920, or in thirty years, and by 1950, it will have again nearly doubled if the ratio remain constant and the government stable and liberal.

It is not to be expected, however, that the ratio will remain constant for so long a period, but it will not be many years before our population will reach 150,000,000 souls.

TO REPRESENT VARIATIONS.

Fluctuations in values may also be illustrated most forcibly by the use of the graphical method.

Take, for example, the relative values of gold and silver during the past century, and plat the curve of their ratios as per the diagram (see *Plate II*), and it will reveal at a glance the relation between the values of those commodities and legislation. The stability of their relative values, from the close of the last century, through three wars and several financial crises, up to 1873, the year of the passage of the demonetization act, is clearly shown, as well as the effects on the ratio due to subsequent acts. This diagram, therefore, is a sharply-defined representation of the fact that the value of silver as a medium of trade has depreciated rapidly, while that of gold has as rapidly appreciated, neither being stable nor a "standard," and, but for the providential development of large deposits and the reduction in the cost of extraction of gold, the discrepancies in values would have been much greater.

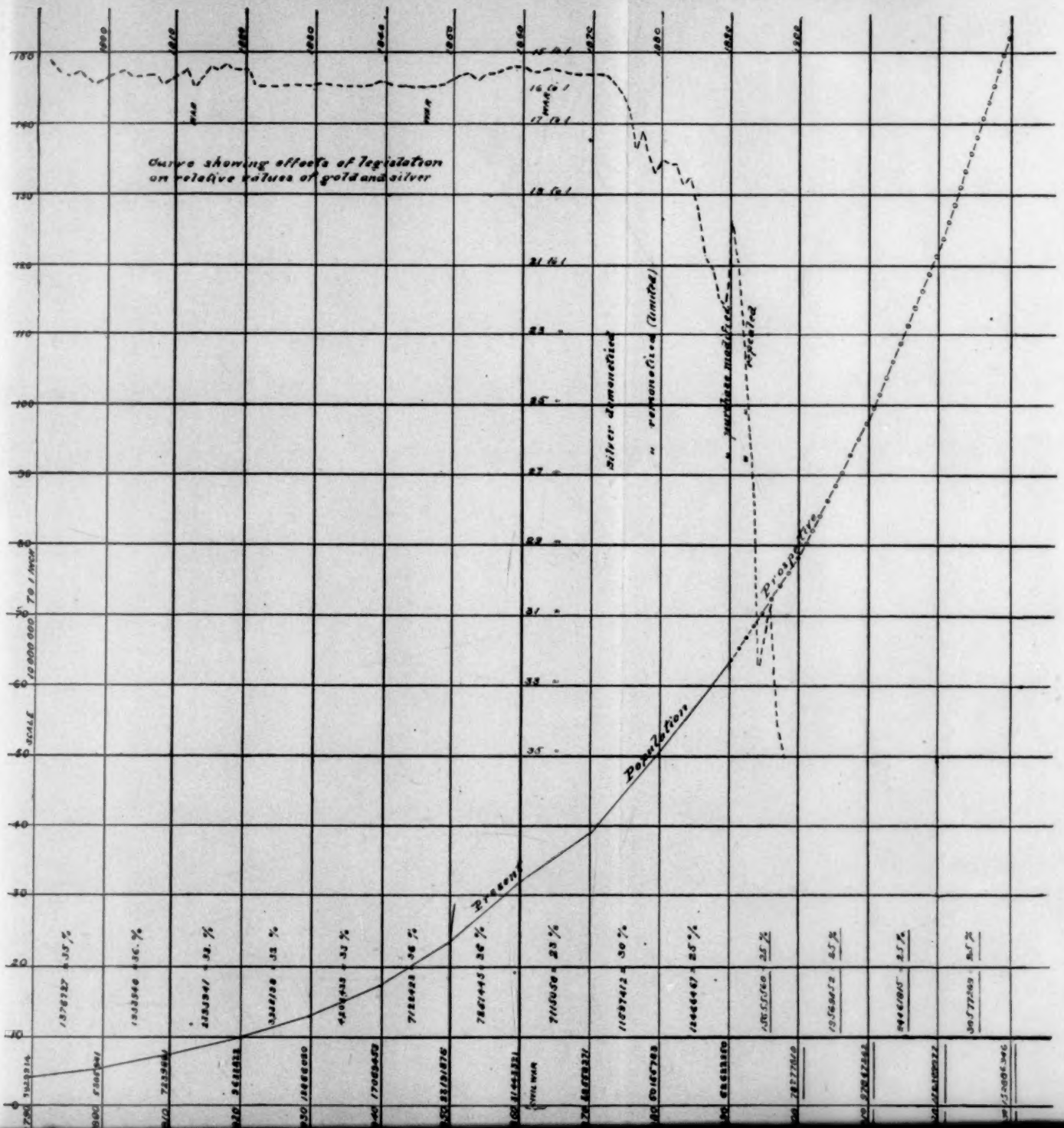
TO DETERMINE FRANCHISES.

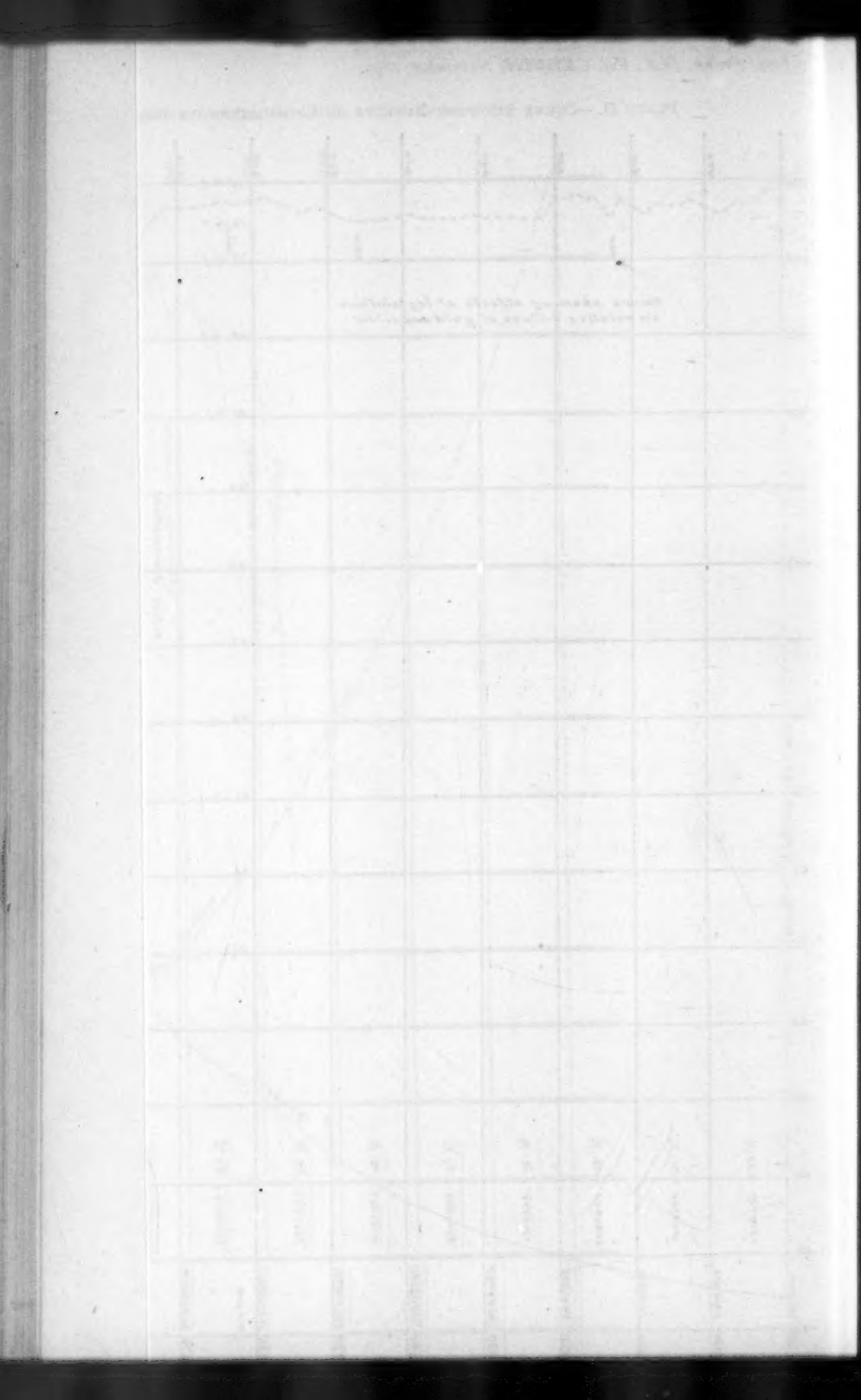
Columns of figures are also confusing when it is desired to determine the values of a franchise from the tabulated annual revenues of any enterprise, and an average of the net returns is also misleading, since the profits will generally be less during the earlier stages of development than in the later year. Here, again, the superiority of the graphical curves plays an important part in revealing at once the actual condition of affairs.

To illustrate: take the case of the Monongahela River Improvement from 1840 to 1896, and plat the receipts and expenses, as shown in *Plate III*. These curves indicate readily the fluctuations due to internal and external causes far better than can be done by an array of figures. If a dam breaks, the expense account goes up and the revenues down; if enlargements or betterments are added, the operating expenses reach a higher plane, while the revenues are correspondingly increased.

But probably the most practical use of this diagram is

PLATE II.—CURVE SHOWING EFFECTS OF LEGISLATION ON RELATIVE VALUES OF GOLD AND SILVER.





to determine the value of the company's franchise by the establishment of the average financial gradient. This is done, approximately at first, by a trial line with an assumed annual increment, and by then taking the algebraic sum of the ordinates of the revenue above and below this line. If

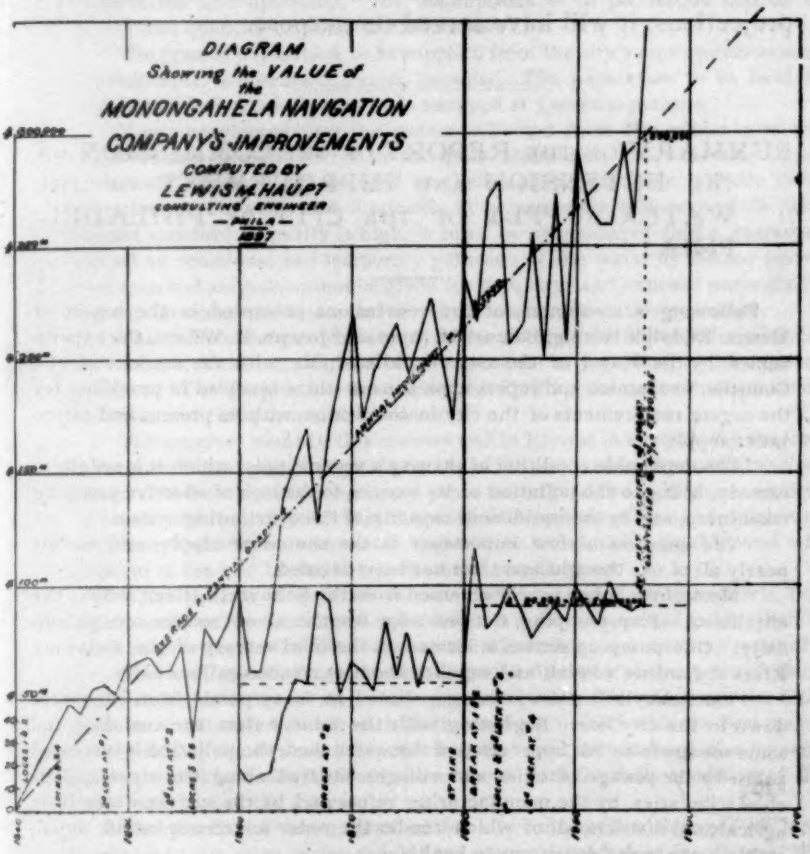


PLATE III.

this sum is not equal to zero, it should be further adjusted until it is so, when the true line becomes known. By capitalizing this increment at the current rate per cent., the value of the franchise is readily found.

These few illustrations will serve, it is hoped, to estab-

lish the great superiority of the linear methods of representing statistics as compared with the pictorial volumes and areas, which are almost useless to the statistician as well as to the public. If this brief article will aid in eliminating so unsatisfactory a method, and in substituting therefor the general use of the more scientific and accepted projections, it will have served its purpose.

SUMMARY OF THE REPORT OF THE COMMISSION ON THE EXTENSION AND IMPROVEMENT OF THE WATER SUPPLY OF THE CITY OF PHILADELPHIA.

Following is a summary of the conclusions presented in the report of Messrs. Rudolph Hering, Samuel M. Gray and Joseph M. Wilson, the experts named by the Mayor of the city of Philadelphia, with the consent of the Councils, to examine and report upon the questions involved in providing for the urgent requirements of the city in connection with its present and future water supply:

"The deplorable condition of the city's water supply, which it is sought to remedy, is due to the pollution of its sources, to the lack of effective pumping machinery, and to the insufficient capacity of the distributing system.

"The question of first importance is the source of supply, and to this nearly all of our thought and time has been devoted.

"Most of the water is now obtained from the Schuylkill River, within the city limits. Five pumping stations take from it about 200,000,000 gallons daily. One pumping station is located on the tidal estuary of the Delaware River at Lardner's Point, and supplies about 15,000,000 gallons daily.

"The Schuylkill water is being polluted at many points from its source down to the city line. Beginning with the mine waters, the coal dust and some sewage from the upper parts of the water shed, the pollution is increased below by the sewage of cities and villages situated along the river and its chief tributaries, by the manufacturing refuse and by the surface water from agricultural districts, all of which render the water sometimes turbid, unpalatable, impure and dangerous to health.

"The Delaware water at Lardner's Point is less turbid after rains than the Schuylkill water; it is also softer and less polluted. Its flow is many times larger. While this water is, therefore, now somewhat better than the Schuylkill water, the growth of the city, the newly-built or projected sewers above and below the intake, and the tidal oscillation of the water, tend to a continually increasing pollution also of the water taken from the Delaware River.

"It, therefore, becomes imperative either to select a new source of supply or to improve the present one, so that it will become thoroughly satisfactory

to the citizens both as to quality and quantity. The first project requires the bringing of Blue Mountain water to the city; the second requires a thorough filtration of the Schuylkill and Delaware waters taken within the city limits. A decision as to which of these alternative projects is the better one must be based on the quality and quantity of water to be supplied and on the cost.

"It was, therefore, necessary first to make certain preliminary assumptions, then to make designs for both projects, and to ascertain the cost of construction and operation. The assumptions as to population and as to quality and quantity of water are as follows:

"The present population, to be supplied from the city's pipe system as soon as practicable, is taken at 1,300,000 persons. The population to be held in view in the design for new works is assumed at 3,000,000 persons.

"It was considered that the waters collected from the affluents of the Delaware and Lehigh Rivers in the Blue Mountains, and from the Upper Perkiomen Creek, could be used in their natural condition. While these natural sources are the best obtainable at a reasonable cost, and while their average standard of purity is high, it must be remembered that a guarantee against an occasional and temporary pollution of the water by disease germs from man and animals cannot be given for such large and exposed water sheds. Nor can an occasional taste, due to vegetal matter, be entirely avoided.

"The alternative source of supply is the water of the Schuylkill and Delaware Rivers, within or near the city limits, artificially purified to the required standard. The purification is obtained by filtering the water through sand: no better and cheaper method is known.

"The progress made in this country and in Europe in ascertaining the laws of the mechanical and biological process of filtration, and the practical success obtained in filtering water for many years in large cities of Europe, confirm and warrant the conclusion that this method of purification can furnish this city, from both rivers, with water that will be clear and palatable, and will conform to the best bacterial and chemical standards.

"When the raw river water carries much suspended matter with it, this must be allowed to subside, as a preliminary to filtration, so as to lengthen as much as practicable the time between the filter cleanings. Settling reservoirs are, therefore, essential as preliminaries to the filtration of the water of these two rivers. In order to secure the greatest practicable efficiency, the filter plant must not only be built with skill, and be provided with the best means for regulating the flow, and for cleaning the sand, but it must also be carefully operated by trained men, in accordance with the daily condition of the river water and of the filters.

"The quantity of water required for city consumption depends on local conditions. In some cities much less water is used than in others. The quantity with which Philadelphia has generally been credited is somewhat misleading, due to the absence of proper measuring appliances; as a matter of fact, it is less than appears on the records. There is also in this city an undoubted waste of water, the amount of which cannot now be accurately determined, and which confers no benefit whatever, either to persons or property, or for street or sewer cleaning. It therefore subjects the citizens at large to an entirely useless expenditure, which should be stopped at the earliest practicable moment.

"We consider that at present a daily supply of 200,000,000 gallons, being 150 gallons per capita, is a very liberal allowance. We recommend that this quantity of pure water be immediately provided for. At the same rate a population of 3,000,000 persons will require a daily supply of 450,000,000 gallons.

"Comparative estimates of cost have been made for eventually supplying these quantities. In order to indicate the legitimate outcome of an extravagant use of water, we have made a further estimate of cost for supplying the city daily with 700,000,000 gallons of mountain waters.

"The Blue Mountain water projects deliver water to the city reservoirs by gravity. In one, mountain water is obtained from the upper Perkiomen Creek and from the Lehigh River, with its tributaries. In another, mountain water is taken from the Delaware tributaries near the Water Gap. Still another project was considered, using the Delaware water at Portland, below the Water Gap, but after filtration. Other projects were considered, but were found to possess no special advantages, and were also more expensive.

"The filtered water project which has been specially considered is confined to taking water from the Schuylkill and Delaware Rivers within the city limits.

"Two methods of filtration are in common use; one allows the water to percolate slowly through a bed of sand, while the other allows it to pass through much more rapidly, and, in order to give it the same degree of purity, requires the use of a coagulating substance to prevent objectionable organisms and suspended matter from passing through the filter. The first we have called a slow and the second a rapid filtration.

"Inasmuch as it has been impossible, in the time at our disposal, to make the necessary experiments showing the precise effects of filtering both the Schuylkill and Delaware waters, either through slow or rapid filters, it is also impossible now to state which of the two systems would be the more economical. But we know, and can positively assert, from experience obtained elsewhere, that, for the plants which we have recommended, a slow filter system will not materially differ in annual expense from a rapid filter system. We likewise know that the slow filters, from long experience, and from their successful operation in many cities, can, without question, yield satisfactory results with the waters of the above-mentioned rivers. The rapid filters have only recently been sufficiently developed to command a high degree of confidence in their results under all circumstances.

"We are of the opinion that for the present supply slow filters should be adopted at every station in the city, excepting at the one near East Park reservoir. We believe that at the latter station a rapid filter plant would be more serviceable.

"A comparison of the estimates of cost shows the following results:

"The most economical project for a supply of mountain water is that taken from the upper Perkiomen and from the Lehigh water sheds. For immediate needs, its cost of construction is $33,410,000. Its annual cost for operation, interest on investment, and all expenses, to deliver the water into the city reservoirs is $1,205,000.

"For a daily supply of 450,000,000 gallons, the total first cost would be $66,740,000, and the annual cost, $2,480,000.

"The most economical project for a supply of filtered water is that by which the waters of the Schuylkill and Delaware Rivers are filtered within the city limits. cost o construction, for present requirements, would be $10,974,000. Its nua cost for operation, interest and all other expenses, to deliver the water into the city reservoirs is $1,227,000.

"For a daily supply of 450,000,000 gallons, the total cost of the filter plant, including special mains from Torresdale to the center of the city, would be $34,155,000, and the annual cost, $2,972,000.

"The estimates of cost have shown three important results:

"(1) The original cost of any of the mountain water supplies is very great for the large quantities of water which the city requires.

"(2) A filtered water supply can be obtained at a first cost which is within the present borrowing capacity of the city, and the plant can be operated at a cost which will not exceed the probable annual net earnings of the water works.

"(3) The total annual cost of delivering the water into the city reservoirs, by either method, is about the same, and the annual earnings will cover the operation and extension.

"In conclusion, we recommend:

"(1) The adoption of that project by which the waters of the Schuylkill and Delaware Rivers, taken within the city limits, are purified by filtration.

"(2) The immediate improvement of the existing plant, in accordance with the detailed recommendations of our report.

"The necessity for the second of these recommendations is manifest. Our reasons for the first are as follows:

"The entire works can be built for a sum which the city can secure at this time through a loan.

"A supply of pure water for the entire city can be obtained within a comparatively short time, and the city can thus at an early day be protected against a continuance of those diseases which are known to be caused by the present polluted water supply.

"A filtered water supply, under skilful management, offers a greater security against the effects of accidental pollution of the water than is possible when the supply is taken from open, unprotected watercourses. Filtration can, without difficulty, be made to render the water thoroughly wholesome.

"The two large rivers at Philadelphia, or even the Delaware River alone, can furnish at all times a quantity of water sufficient for a very large city."

Upon the subject of "Filtered Water Supplies" the experts outline the prospective plan of supply for this city in the event of the adoption of the plan agreed upon as most desirable and approved by the Mayor. The report says:

"The slow filters are all designed for an average rate of 3,000,000 gallons of water per acre of effective area (about 9 cubic feet per square foot) per day. The number of filter beds erected at each site at first would be only for present demands, and each plant could be increased thereafter from time to time, as found necessary, by additional filter beds, ample ground having been reserved for this purpose, except in the case of the Queen Lane.

"The area available for slow filters at Queen Lane is limited, so that pro-

vision cannot be made at that site to filter more than 58,000,000 gallons per day, although the amount used in that district will hereafter be considerably greater. This deficiency will be made up from East Park, and for that purpose high-service pumps at East Park will be required.

"A rapid filter plant has been adopted at East Park.

"In considering the Schuylkill and Delaware Rivers as sources of supply to be filtered for the city, we have decided upon the following main points:

"(*a*) To utilize and adopt the present plants as far as possible and to the best advantage.

"(*b*) To use the Schuylkill water for the districts of Belmont, Roxborough and Queen Lane, with such surplus as may remain of the limited 150,000,000 gallons supply per day for East Park.

"(*c*) To abandon the reservoir at Fairmount, which is now in use only for about seven months in the year, and to connect the turbine pumps with Spring Garden station, so that they may be placed in service whenever the supply of water will allow, thereby relieving the steam plant of a corresponding amount of work.

"(*d*) To abandon the Corinthian reservoir.

"(*e*) To retain the Fairhill reservoir, which, although not now designated for use, will hereafter undoubtedly be found valuable as a center of distribution for filtered water, and can be so adapted by modification and covering.

"(*f*) To adopt slow filtration for Belmont, Roxborough and Queen Lane districts, and rapid filtration for such remaining portion of the Schuylkill water as is delivered at East Park.

"(*g*) To establish a slow-filter plant on the Delaware River, below Torresdale, from which all the water not supplied from the Schuylkill will be obtained.

"(*h*) To make use of the present reservoirs, whenever possible, for sedimentation and for the storage of filtered water.

"(*j*) To allow at least twenty-four hours for sedimentation, and to provide storage capacity for one-half day's supply of filtered water.

"(*k*) To cover all storage reservoirs for filtered water.

"(*l*) To cover all filters.

"It is, of course, eminently desirable that the water supplies for filtration should be as free from impurities as possible, so as to reduce to a minimum the duty on the filters; and every effort should be made, by legislation and otherwise, to prevent the pollution of streams; yet such water as exists to-day, in the Schuylkill and Delaware Rivers at the city of Philadelphia, can be purified by filtration and rendered wholesome and fit for all domestic purposes.

"Within the city limits it is possible to locate the filter plants at places where the water supplied to them will not be subject to direct sewage pollution. A point can be selected on the Delaware River within the city limits, but above such direct contamination, and the present intakes on the Schuylkill are well situated in this respect. The locations and conditions of existing pumping stations and reservoirs are such that it is advisable to continue the use of the water in this river up to a quantity equal to its minimum flow, at least so long as the present plant can be made serviceable. For additional supply, and for future extensions, the Delaware is the proper source, and in time it is not impossible that the whole supply may come from that river.

"In order to ascertain the suitability of certain sands, obtainable in the vicinity of Philadelphia, for use in filter plants, we have had mechanical analyses made of a number of samples. The results which are given indicate that there will be no difficulty in obtaining suitable material for the purpose.

"If the annual rates remain the same, the surplus earnings of the Bureau of Water would, to all appearances, be sufficient to pay for the continual extension of the plant as required by the growth of the city.

"Owing to the improvements constantly being made in the operation of filtration plants, it is probable that our estimated cost of filtration will be found, in the future, to have been too high, rather than too low.

"It will be noticed that the estimated cost of filtering on the Delaware is slightly less than on the Schuylkill.

"When the present reservoirs are converted into settling reservoirs for use prior to the filtration of the water, it will be necessary, in some instances, to readjust the water intakes and outlets, so as to accomplish the highest possible degree of sedimentation during the time that the water is passing through the reservoir.

"It is advisable that filters and clear water reservoirs be covered or roofed, to prevent the formation of ice on the surface and to protect the filtered water from pollution by the dust in the air, which carries the seeds of lower life. There is abundant evidence of the deterioration of filtered water or of spring water kept in open reservoirs. In covered reservoirs the water is also cooler in summer than when exposed to sunlight. There is an erroneous idea that sunlight and air are advantageous to stored water. The contrary has been frequently demonstrated, and every one appreciates the excellence of spring water, which issues, so to speak, from the bottom of a large natural filter, without having been exposed to either sunlight or air. There are both chemical and biological reasons for these facts.

"The slow filter plants contemplated in our recommendations are similar, in general arrangement, to those of London and of Hamburg, and to the recently completed filter plant at Albany, N. Y. The latter is the largest filtration plant in this country.

"We have said that we consider it inadvisable during dry years to obtain a greater amount of water from the Schuylkill River than 150,000,000 gallons per day. A provision for supplying the city with 200,000,000 gallons daily, therefore, requires 50,000,000 gallons a day to be obtained from the Delaware River; and all future increase in supply is assumed to be taken from this river. We have selected the neighborhood of Torresdale as the site for the new pumping station on the river, because the present site at Lardner's Point will, in our opinion, not be suitable in the future on account of the several large sewers now delivering, or which will soon deliver, a large amount of sewage into the river in that neighborhood.

"From data at hand and from our estimates of the growth of the city, we have made the distribution of the total daily quantity of water required as follows:

"For a supply of 200,000,000 gallons per day:

	Gallons Daily.
Belmont Station	27,000,000
Roxborough Station	15,000,000
Queen Lane Station	58,000,000
Spring Garden Station	50,000,000
Torresdale Station	50,000,000
Making a total of	200,000,000

"It is proposed to add, at Belmont station, one new pumping engine of 20,000,000 gallons daily capacity.

"For a supply of 300,000,000 gallons per day:

	Gallons Daily.
Belmont Station	37,000,000
Roxborough Station	25,000,000
Queen Lane Station	58,000,000
Spring Garden Station	30,000,000
Torresdale Station	150,000,000
Making a total of	300,000,000

"It is proposed to erect, at East Park filter plant, two 12,000,000-gallon pumping engines, to pump from East Park reservoir into the Queen Lane district, in order to supply the deficiency between the amount pumped directly at Queen Lane station and the consumption of Queen Lane district.

"For a supply of 450,000,000 gallons per day:

	Gallons Daily.
Belmont Station	55,000,000
Roxborough Station	37,000,000
Queen Lane Station	58,000,000
Spring Garden Station	—
Torresdale Station	300,000,000
Making a total of	450,000,000

"If the future water supply is obtained from the rivers and filtered, it will be necessary to make a few changes in the pumping machinery and reservoirs.

"At Fairmount, the reservoir is too low for a proper service, being only 94 feet above tide. Also, it is inexpedient to filter the water at this station, and for these reasons we have recommended the abandonment of the Fairmount reservoir.

"The Spring Garden reservoir would be of no use in the new apportionment, and might be abandoned as a reservoir, unless retained for the use of Girard College.

"At Belmont, the present reservoir, with slight alterations, could be used as a settling reservoir. A new 20,000,000-gallon pumping engine should be added to the station at the Schuylkill River, to be used as a reserve.

"By limiting to 150,000,000 gallons per day the amount of water to be obtained from the Schuylkill River, it became necessary to reapportion the amounts to be supplied to each station, as it was evident that at the present time more than the above amount is actually pumped from the Schuylkill River. We found it to be more economical, therefore, to limit the amount of water to be supplied to the Queen Lane district from the Schuylkill River, and to furnish the deficiency hereafter from the Delaware River.

"The quantity thus supplied to the Queen Lane district from the Schuyl-

kill River is to be secured from the East Park reservoir by a new pumping station at the East Park filter plant, with proper engine capacity to pump from this reservoir into the Queen Lane district.

"A portion of the Queen Lane reservoir is to be converted into a clear-water reservoir discharging into the city mains.

"The East Park reservoir, being very large, will not only serve as a storage reservoir for Schuylkill water, but also for the excess delivered in the future from the Delaware River. A part of this reservoir is to be converted into a clear-water reservoir delivering into the city mains

"The new Roxborough reservoir is to be kept in use, but a part of it is to be converted into a clear-water reservoir.

"The Mount Airy reservoir will be used and the old Roxborough reservoir may be temporarily put out of use.

"The Frankford reservoir will be converted into a clear-water reservoir.

"The Lehigh reservoir can be temporarily placed out of use, and eventually converted into a clear-water reservoir if found necessary.

"In assigning the quantity of water to be supplied to the several districts, and the capacity required of the filtration plant for each, consideration has been given to their probable relative growth and increase in population, as some districts, particularly those of suburban character, will undoubtedly show a much greater annual increase than others.

"The lower levels in the Roxborough district, now supplied from the new reservoir, with its great elevation of 41 feet, could be more economically supplied from the Queen Lane reservoir if proper mains were laid for the purpose. Indeed, a portion of the lower Roxborough district is already supplied by a main which taps the Queen Lane pumping main near the station.

"In connection with the gravity supply from the Delaware River, a new distributing reservoir near Olneyville, at the point of discharge of the conduit, is proposed. The cost of this reservoir is estimated at $1,000,000.

"A new reservoir at Belmont, adjoining the present reservoir, for the sedimentation of raw water, may be required when the present consumption has been materially increased. It probably need not be more than half as large as the reservoir recently proposed

"As the demands of the Belmont, Roxborough and Queen Lane districts increase, the surplus of the Schuylkill water delivered at East Park during minimum flow will gradually diminish; and this deficiency, together with what will be required for increased consumption all over the city, is to be supplied from the Delaware through the Torresdale filter plant. When the Schuylkill is flowing above its minimum, which will be during most of the year, the supply will be ample to keep the East Park plant in full service as well as the others.

"To abandon completely at this time the present Schuylkill plants would mean the abandonment of much valuable pumping machinery and other works, and also a loss of time in making the change. This change would require not only that a large additional plant be in operation on the Delaware before the Schuylkill plant could be removed, but also the laying of large and costly mains to bring the water to the city.

"Upon the completion of the proposed Torresdale pumping station the Frankford station would be abandoned.

"The standpipes at Belmont, Roxborough and Chestnut Hill will be kept in use, but will be supplied with filtered water instead of with raw water."

On the subject of water meters the experts say:

"No restriction should be placed upon the use of water required for health, comfort and cleanliness, nor should a part of the community be encouraged to deprive another part of its full quota of water. We are, therefore, emphatically of the opinion and strongly urge that all practicable means should be adopted to secure a fair and equitable distribution of the city's water.

"We know of no better means to this desirable end than the introduction of water meters, not only for all business properties and manufacturing establishments, but also for such private consumers as are found by the Department of Public Works to be carelessly wasting water from the public supply. This remedy is available and simple, and it has been already adopted in many cities with entire satisfaction.

"We earnestly recommend the introduction of meters for the city of Philadelphia with perfect confidence that the private consumer is given full and ample use and enjoyment of all water for his needs and comforts at no greater cost, and probably in many cases even less cost than the present rates impose. The meter is not proposed to increase the revenue, but to prevent one citizen from depriving another one of his rightful share of water. A private corporation would introduce meters at an early day if not restricted by law, and would at the same time encourage consumption in every way.

"The lack of a sufficient supply of water in various parts of the city is due either to a deficiency of distributing pipes, to the lack of pressure from the reservoir, to the want of pumping machinery, to a waste of water which reduces the head, or to two or more of these causes combined. The remedies are apparent."

NOTES AND COMMENTS.

SURVIVAL OF AN ANCIENT INDUSTRY.

Among the many industries connected with the iron and steel trades, there is one survival from former times in England, which is of great interest. This is the mail chain armor manufacture in Walsall. J. W. Hawkins & Co., Limited, who contract with the Government for the supply of spurs, bits, stirrups, harness, buckles, chains, etc., also supply mail chain jackets and other steel productions for use in India, Central and South America and other countries. These jackets of mail, which weigh from 15 to 18 pounds, are worn by army officers, and sometimes by Indian native princes, and are made of steel rings of ⅜ inch diameter. It takes about 3,000 rings to make a square foot of armor. These rings are formed out of soft steel wire of 14, 15, 16 or 17 B. W. G., which is revolved around mandrels 4 inches long, and of the same diameter as the rings required, each mandrel taking about 6 feet of wire, and subsequently divided by a hand saw. Hardening is accomplished by putting them upon trays and plunging them when red hot into oil, after which they are polished in revolving drums.

DISCOVERY OF A NEW PLANET.

Herr Witt, of the Berlin *Urania*, has announced the discovery of a new member of the solar system, which is now affirmed to be a new planet revolving round the sun in a strongly elliptical orbit, between the Earth and Mars, in a period of 645 days.

It is assumed that the new body entered the planetary system recently as the "result of some disturbing influence on the part of one of the large planets." The presence of the newly-described planet has been confirmed by Charlois, at Nice, who has taken photographs of it simultaneously with Witt at Berlin.

PHOTOGRAPHING PROJECTILES IN FLIGHT.

In discussing some curious phenomena observed in studying the flight of projectiles, the *Engineering Magazine* mentions the interesting fact, in connection with the successful taking of projectiles in flight, that, "since no shutter could be made to act quickly enough to make the brief exposure necessary for these photographs, and as correct timing would be impossible, the bullet itself is caused to make the exposure by making an electrical contact between two wires, just as it passes the center of the photographic field, thus closing the circuit of a Leyden jar, and producing a bright spark, which furnishes the illumination for the photograph. The bullet is thus reproduced in silhouette."

SILICATE OF SODA (WATER-GLASS) IN REFINING PETROLEUM.

Drugs, Oils and Paints recommends highly the use of silicate of soda for the refining of the heavy (spindle to cylinder oils) petroleums. The silicate is used as a neutralizing agent after the treatment with sulphuric acid, and is said to be highly efficacious. It may be used either alone or in connection with caustic soda.

Its advantages are said to be:

(1) A smaller percentage of sulphuric acid may be used for heavy oils; although dark oils are thereby obtained, the decolorizing property of the separated silicic acid soon changes them into pale oils, which are readily salable.

(2) The emulsion deposits quickly, through the agency of the separated silicic acid, which acts upon the suspended impurities as a precipitating agent.

SOLID PETROLEUM.

Attempts have been made from time to time to solidify petroleum refuse for use as a fuel. The latest effort in this direction, says *Industries and Iron*, is that of Herr Kohlendorfer, a Bavarian. In his process about 10 per cent. of soda lye, with 10 per cent. of fatty matter, is treated in a boiler, and enough petroleum refuse is added to the heated mass to make up 100 parts. This mixture is then heated, under constant stirring, for about an hour. The temperature is prevented from reaching the boiling-point of petroleum. In this incipient state of saponification the mass acquires the property of taking up large quantities of fluid rock oil. The mixture is run into moulds and allowed to cool, when it may be cut into pieces of any desired form.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, October 18, 1899.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 18, 1899.

MR. JAMES CHRISTIE in the chair.

Present, 78 members and visitors.

Additions to membership since last report, 23.

The following gentlemen were, on the recommendation of the Board of Managers, elected as honorary members, viz.:

Prof. Harvey W. Wiley, Washington, D. C.
Dr. Chas. F. Himes, Carlisle, Pa.
Dr. Edwin J. Houston, Philadelphia.
Mr. Ralph W. Pope, New York.
Mr. Chas. Kirchhoff, New York.
Mr. John Fritz, Bethlehem, Pa.
Dr. Coleman Sellers, Philadelphia.
Dr. T. C. Mendenhall, Worcester, Mass.
Rear-Admiral Geo. W. Melville, U. S. N.
Dr. Rob't H. Thurston, Ithaca, N. Y.
Hon. Frederick Fraley, Philadelphia.
Prof Martin H. Boyé, Co.persburg, Pa.
Hon. Abram Hewitt, New York.

The following were elected as corresponding members, viz.:

Mr. T. Commerford Martin, New York.
Mr. Wm. F. Durfee, West New Brighton, N. Y.

Amendments to the by-laws were approved, reducing the distance-limit for non-resident members to twenty-five miles from Philadelphia; also, permitting non-resident members to make a life-membership payment of forty (40) dollars, in lieu of annual fees.

Mr. B. S. Lyman, Chairman of the Committee on Library, represented the need of facilities for the proper storage of the large pamphlet collection of the library, to make the same safe and accessible.

The Secretary called attention to the newly-established School of Naval Architecture, and to the annual announcement and program of lectures just issued.

The papers of the evening were read by Mr. Strickland L. Kneass, on "Giffard's Invention and the Development of the Self-acting Injector," illustrated by models and diagrams; and by Mr. Wm. B. Wait, Superintendent of the New York Institution for the Blind, on "An Apparatus for Embossed Printing for the Use of the Blind," illustrated by specimen machines.

The subjects of both papers were referred to the Committee on Science and the Arts for examination and report.

The Chairman expressed the thanks of the meeting to the speakers of the evening.

Adjourned.

WM. H. WAHL, *Secretary.*